River Conservation Planning with the Vermont River Conservancy

Middlebury College
Environmental Studies Senior Seminar

Spring 2005

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The Environmental Studies Senior Seminar (ES401) is a key component in the Environmental Studies major, and is intended to be 'interdisciplinary capstone' of the ES major here at Middlebury College. This class seeks to integrate the broad wealth of knowledge that students have developed within in our diverse range of individual foci. Furthermore, through collaboration not only within our academic world of Middlebury College but also with a community partner, this class provides students the opportunity to apply their knowledge to real and pertinent local or regional issues regarding the environment. Intentions of this class include providing new perspectives to students regarding our local Vermont community, further refining of both written and oral communication skills, and increasing confidence and comfort in working through 'real-life' environmental issues affecting local communities. However, the main onus of this course is on collaboration. With this background in mind, our spring of 2005 ES401 class began a collaboration with our community partner, the Vermont River Conservancy that focused on a stretch of the Otter Creek.

Part I. Introduction

The Vermont River Conservancy (VRC) is a statewide non-profit organization with the mission to protect land along Vermont's exceptional water resources. In operation since 1995, the VRC has recently moved its offices to the town of Middlebury, opening the door for collaboration with the college. To protect Vermont's riparian heritage, the VRC has established several specific objectives, including: protection of 'special places' such as waterfalls, gorges, swimming holes, wetlands and islands within Vermont waters; protection of wildlife habitat, natural communities, and biodiversity along Vermont waterways; protect lands for recreation, education, and aesthetic enjoyment; and facilitation and encouragement of additional land protection and stewardship along river corridors (Meyers, 2004).

With the Vermont River Conservancy as a community partner, our Environmental Studies Senior Seminar class focused on the issue of river conservation. In particular, our goal was to address conservation concerns along a portion of the Otter Creek. Our study site was contained to the north by the Vergennes Dam in Vergennes and by the Route 17 bridge to the south, forming an approximately ten-mile stretch that includes a parcel of land previously identified by the VRC as an area of interest. Currently for sale, the Bourgeois property has been identified as an "at risk property," one with serious threats of development. Working within the objectives of the VRC, the

goal of our work was to provide the organization with the information required to recognize the potential of the natural habitats and ecological processes along the Otter Creek. With the recognition of the opportunity to create a stretch with high biological integrity and health, we additionally sought to present the VRC with options and analysis of protection methods for this region.

As mentioned above, our focus, in the broadest sense, was on river conservation. Through class discussions and readings, we familiarized ourselves with this issue, first at a national scale and then gradually at a more local scale. Throughout human history, we have been tied to rivers and waterways; early civilizations sprang up in river valleys and floodplains (Postel and Carpenter, 1997). Humans have long relied on rivers and waterways for goods and resources including water supply, energy production, irrigation, transportation, fisheries and food resources, water, medicines, waste disposal, and recreation (Doppelt et al., 1993). To maximize our benefit from these water resources, we have a long history of river modification dating back at least 5000 years (Allan, 1995). Continual extraction of resources and this history of modification has had an inevitably impact on the state and conditions of the world's waterways. Today, nearly all forms of riverine and riparian biodiversity are endangered. In the United States, a third of all native fish are currently listed as threatened or endangered (Doppelt et al., 1993). Less visible aquatic species show even greater degrees of degradation, as 65% of crayfish and 73% of unionid mussels are endangered or threatened (Doppelt et al., 1993). The impairment of the aquatic biologic communities suggests a serious and extensive degradation of our water resources. This degradation is only further highlighted by the fact that 70-90% of natural riparian vegetation has been lost to human activities and that 70% of rivers nationwide have altered flows. Furthermore, according to the Ohio EPA, 50% of the nation's water fails to meet water quality standards (Doppelt et al., 1993). These figures begin to illustrate the extent of destruction that has occurred in our nation's waterways. Understanding that riverine

systems are indicative of the health of the surrounding landscape (Doppelt et al., 1993), this drastic decline in our aquatic ecosystems' health implicates a similar progressive decline in terrestrial ecosystems. The damage observed in aquatic systems suggests an erosion of the earth's ability to support living systems, and, as an extension, human societies (Doppelt et al., 1993).

The continued and unabated destruction of our aquatic ecosystems' health has been attributed in part to a false perception that rivers are nothing more than water flowing through a channel. With this view, there is a complete separation of and no interaction between terrestrial and aquatic worlds. In actuality, rivers are much more dynamic systems. Considering a more holistic approach, viewing rivers through a watershed perspective connects river systems with the land through longitudinal (upstream-downstream), lateral (floodplains-uplands) and vertical (groundwater/hydric soil-stream channel) processes, all of which have temporal dimensions as well (Doppelt et al., 1993). In this manner, the watershed perspective brings a multi-dimensional approach and understanding to riverine systems. With this approach, catchment areas or watersheds can be described as a geographic landscape feature that collects all water and drains to a common source. John Wesley Powell has defined watersheds as "that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course"(EPA website). Adopting such a watershed perspective is imperative for river conservation planning.

In Vermont's agricultural landscape, the implementation of riparian buffers, a technique incorporating the watershed perspective, is one of our most practical river conservation tools. Riparian buffer can be defined as a vegetative strip, ranging from grass to forested land, which forms an interconnected transition between terrestrial and aquatic lands. Such buffers serve to help protect water quality, aquatic and terrestrial habitats, channel and floodplain stability, and wetlands; additionally, these landscape features have social and economic values attributed to them (McLain, 2005). Buffers facilitate water quality protection through the retention of sediments and nutrients

(Brinson and Verhoeven, 1999). We have found this issue to be of particular importance here in Vermont, where much attention has been recently given to water quality in Lake Champlain. This lake, forming the collecting pool of one of the four great watersheds covering Vermont (Klyza and Trombulak, 1999), has become overloaded with phosphorous to such an extent that nearly all of the lake water fails to meet water quality standards. In accordance with the watershed perspective, we believe that much of this degradation is occurring long before water reaches the lake. Rivers such as the Otter Creek become laden with nutrients as they pass through the landscape before emptying into Lake Champlain. Thus, efforts to curb the nutrient overloading of this water body should initiate upstream in rivers. The Otter Creek is Vermont's longest, flat-water river. Flowing 100 miles through 44 towns from its headwaters in Mt. Tabor to its mouth in Lake Champlain, the Otter Creek drains a sub-watershed of 1100 square miles. In this project, we focused our attention on the ten-mile stretch of the Otter Creek between the upstream Route 17 bridge in the town of Weybridge and the downstream Vergennes hydroelectric dam.

The Vermont River Conservancy's interest in this particular stretch of the Otter Creek stems from Vergennes citizens. Concerned residents of this town approached the VRC when the Bourgeois property, a 110-acre farm parcel, was put up for sale. Fearing possible development if this land was sold, the citizens asked the VRC to consider the possibilities of acquiring the land. No longer an active farm, the property is zoned for agricultural purposes and thus cannot be sold in parcels smaller than 5 acres. With nearly one-third of the area classified as wetland, there has been an application submitted to the Wetland Reserves National Fund for Easements. While the VRC has not acquired the land, it does maintain a common interest with the Vermont Forum on Sprawl and the Bourgeois brothers to, at minimum, protect the wetlands on the parcel.

Working with our community partner, the Vermont River Conservancy, we investigated the conservation concerns of biological and ecological processes within this reach. We sought to

develop an understanding of the current state of natural resources on the river, the potential for recreation in this stretch, and establish connections with landowners to begin to address modifications of harmful behaviors. To achieve these goals, our class formed three task groups with the individual foci of conducting an historical change analysis, establishing an understanding of the current condition of the river, and preparing conservation strategies to effect change on the Otter Creek. More specifically, the change analysis task group determined the extent of change in land use and the river corridor over the past sixty years. The current conditions task group focused on the present state of the area to propose buffer options and highlight areas of conservation importance. The strategies group used this compiled information to determine the socio-economic impact of the proposed buffer options, and to open avenues of communication with landowners through interviews about their opinions and feelings in regards to conservation efforts involving their property on the Otter Creek.

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Part II. Historical Change Analysis

Introduction

Our group's goal was to use a Geographic Information System (GIS) to assess land use/land cover (LULC) changes in the land surrounding Otter Creek between Weybridge and Vergennes. We decided to set the boundaries of the study area to the roads nearest the creek on either side, since this is the area in which land uses have the greatest direct impact on the river and in which riparian buffers would be implemented. Analyzing aerial photographs from 1942, 1962, and 2003 we set about digitizing LULC types in order to understand how changes may be affecting the health of Otter Creek. We hoped to use our results as a tool for conservation and land management decisions, especially for our own strategies group.

Methods

To perform our change analysis, we digitized aerial photographs of the study area from 1942 and 1962 and compared these photographs to those taken digitally in 2003. All of the photos were taken during the month of May. The 1942 and 1962 photographs were black-and-white contact prints. The 2003 photographs were National Agriculture Imagery Program (NAIP) digital color orthophotos.

The study area includes the length of Otter Creek from the dam in the town of Weybridge to the dam in the town of Vergennes in Addison County, Vermont. The stretch of Otter Creek included in the imagery was approximately 10 miles in length and was composed of a number of individual aerial photographs, which we lined up to cover the entire area in the 1942 and 1962 images. We used the Photomerge function within Adobe Photoshop to match identical pixel patterns and join the individual images into a single image. Because of inconsistent flight paths in 1942, we were forced to use separate east and west images of the river corridor only for the 1942

photos. Images from 1962 were successfully merged. Using a georeferenced shapefile of Vermont roads, we georeferenced the aerial imagery. Our RMS error was less than 15 m. The 2003 digital imagery was already georeferenced.

Using the same georeferenced shapefile of Vermont roads, we digitized a polygon that bounded the river based on the nearest major roads. From the encompassing polygon, we cut polygons that represented the river corridor, as well as land use/land cover types for each of the three years.. The LULC types that we digitized were forest, cultivated fields, uncultivated fields, partial cover, developed, and orchards (Table 1). We digitized swales, riparian buffers, and farm roads into a polyline shapefile, and marked developed lands by points and a point shapefile. We calculated the area of each land use polygon using the 'area' calculation in ArcGIS. The attributes associated with each polygon were identification number, LULC, and area (acres).

Table 1. Land use/land cover types and descriptions

Land use/cover type	**Description**
Forest	Dense tree coverage
Cultivated	Hay and crop fields, typically harrowed
Partial woody cover	>30% shrub and/or tree cover
Uncultivated field	Pasture, abandoned field, etc.
Developed	Residential and farm structures
Orchards	Evenly-patterned fruit tree cover

Results

In our study area, we found an overall decrease in cultivated land between 1942 and 2003 and increases in all other land use categories (Figure 1). 474 acres of lands used for cultivation in 1942 were used for other purposes in 2003. Developed land in the area doubled from 87 to 183 acres; the gain was mostly in small patches throughout the study area, but also in some developments outside of Vergennes. There were nearly 200 more acres of forested land in 2003 than in 1942, mostly due to a large forest patch that developed in the middle of our study area. Uncultivated fields experienced an increase of 169 acres, due to land use changes in the southeast corner of our study area. Partial cover increased by 105 acres, due primarily to increases along the

river. By 2003, there were no orchards found in the area, and this land use type was therefore discarded from our analysis. Additionally, flaws with the aerial photographs from 1942 and 1962 made it impossible to match up the river corridors to either analyze precise spatial changes in the study area or changes in stream geomorphology over the 61 year study period. Nevertheless, visual analysis suggested that the river meanders and width had changed little in that time.

Discussion

Three main trends from our findings indicate potential changes in river corridor health: the decrease in cultivated land (and associated increase in uncultivated land), the increase in forest and partial woody cover, and the doubling of developed land. While it is impossible to make an overarching assumption of whether river health is in decline or is increasing, it is useful to look at the individual land-use shifts occurring in the watershed to understand some of the changing inputs to the system.

The large decrease in cultivated land between 1942 and 2003 was largely made up by an increase in uncultivated fields. What we have seen over the 61 years is a decrease in row crops and planted hay, coupled with an increase in land that is either used for grazing cattle or has been abandoned from agriculture. The benefits to river health of having land out of cultivation are unquestionable. A substantial proportion of the lands in our study area are flood every year, and fertilizers, pesticides, and pollutants from machinery are flushed into the river leading to eutrophication and toxicity in the water. A study on Deschutes River in Oregon shows that having land in agricultural production as compared to forested land increased runoff by 386,000 acre-feet per year (Shelton, 1981). Certainly taking land out of agricultural production would help to lessen this massive runoff problem. This has implications for both plants and animals in the river. Changes in water chemistry can severely alter the species composition and abundance of aquatic ecosystems. Therefore, a decrease in such inputs is good for river health.

On the other hand, an increase in lands that could potentially be used for grazing has significant implications. Wastes from cows run straight into the river, thus altering nutrient regimes. Additionally, cattle tend to congregate in riparian areas, making for a more direct input of nutrients to the river regardless of weather patterns (Fleishner, 1994) It is important to note though, that manure is being put into the river whether the land is grazed or is cultivated; the cultivated fields receive a more intensive, episodic input since large amounts of manure are applied as fertilizer several times throughout the year. Our analysis did not attempt to show which lands were grazed and which were unused fields. With this knowledge, perhaps it would be easier to quantify inputs into the river from land-use practices.

The increase in forested and partial cover land types is a positive sign for the health of the river. Forests and partial cover, especially those located adjacent to the river, have the potential to sustain river health. Forests control erosion, which is an especially large problem along this section of the creek, as we saw from our bed and bank windshield survey. Forests are also important filters of runoff from adjacent agricultural, grazing, or developed lands. Comparing forests to cleared land in the Deschutes basin, Shelton (1981) found that forested lands helped to retain 560,000 acre-feet of runoff per year. Another ecological benefit of forest patches is that they provide habitat for riparian organisms, as well as serve as movement corridors for animals. As more and more forest appears in the watershed of Otter Creek, river health will be on the rise.

Our study area is rural, except for the small urban portion in Vergennes, and a doubling of developed lands is a significant change in this context. Converting land to development has a number of negative impacts on the river. Stormwater runoff from roads, driveways, and households adds a completely different set of inputs to the river: road salts, nitrogen, phosphorus, sewage, and garbage - the list goes on. A study by Soranno et al. (1996) showed that a near doubling of urban lands in a Wisconsin watershed, especially in regards to phosphorus runoff, would have disastrous

effects on water quality. However, the nature of development in the study area has not been increasing urbanization or concentrated development, but rather there has been residential development of small parcels spread evenly throughout the area. Networks of new roads have not been created, and land use around the town of Vergennes remained relatively the same. This is an indication that although there certainly is an impact on river health, a doubling of development in a rural area such as this does not necessarily have the same implications as a doubling of developed lands would in a more urban setting, like the study by Soranno et al. (1996) in Wisconsin. Because of a lack of new roads, and because the development is occurring at the level of individual households spread throughout the study area, increases in stormwater runoff should be relatively small.

To summarize the ecological implications of our findings, we found an overall decrease in cultivated land, with associated increases in all other land-use types. The decrease in cultivated land has probably had positive impacts on river health. However, it is important to note that farming practices have changed over the 61-year study period, and it is therefore very hard to quantify changes in inputs to the river ecosystem. The increases in forest and partial woody cover have very likely had positive impacts on river health by controlling erosion, filtering runoff, and increasing habitat for wildlife. Finally, while the doubling of developed land is sure to have caused increased inputs of commercial waste products, the nature of development is such that these inputs are very dispersed and minute.

Our analysis has helped to shed light on how the Otter Creek watershed is changing over time, and to give some suggestions for how river health is varying with changes in land use. Our findings over the study time period indicate that maybe the river is in a little better shape than it was 63 years ago. However, our GIS work needs to be augmented with solid fieldwork in order to fully comprehend the issue and make educated management decisions.

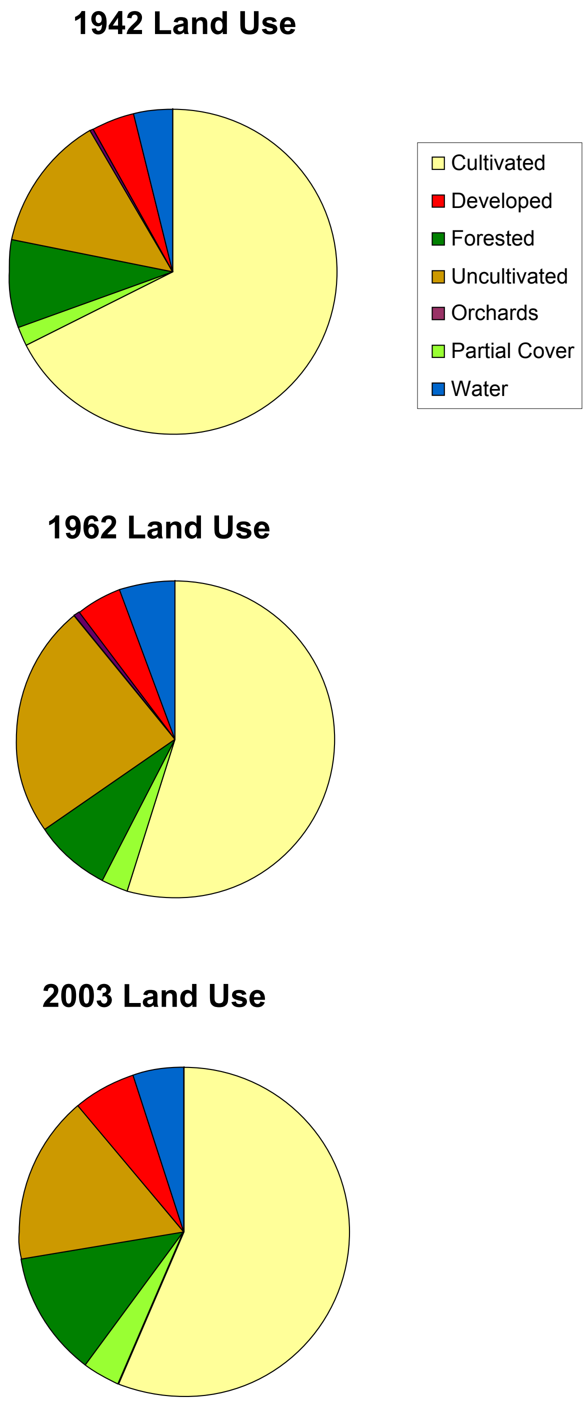

Figure 1. Changes in land use in the study area between 1962 and 2003. Note the large decrease in cultivated land, and the large increases in uncultivated and forested lands.

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Part III. Current Conditions of the Otter Creek

The current conditions group sought to establish the present ecologic and geomorphic conditions within our reach of interest, assess floodplain extent, develop a minimum zone of protection, evaluate different riparian buffer options and present our findings in a useful and dynamic manner. Our data collection involved gathering information layers from the Vermont Center for Geographic Information, Addison County Regional Planning Commission, and the Middlebury College Department of Geography. We created additional layers by digitizing land-use/land-cover orthophotographs and fieldwork findings along the reach of the Otter Creek on which we focused. Two phases of fieldwork were completed to verify data: road commissioner interviews and in-stream geomorphic assessment and ecologic assessment. Analysis of our compiled information considered conditions in and surrounding the study area to create buffering options based on guidelines from the Agency of Natural Resources, the Center for Watershed Protection, and the Geomorphic Corridor Criteria.

Digitizing

Introduction

In digitizing the 2003 Addison County orthophotography, our goal was to establish a fine-scale and current view of the land use along the Otter Creek study area, in order to aid in riparian buffer planning. The development of such an analysis facilitates the quantification and comparison of the area of each land-use category. The land use digitization can reveal where riparian buffers exist along the river, and when not present, what land use/cover types abut the river. Knowing the amount of riparian protection allows us to identify the extent of conservation that needs to be addressed.

Land uses removed some distance from the river bank can still impact its condition through the movement of surface water. Thus, the digitizing of surface water paths expands the knowledge concerning which land use types will impact the river and therefore require buffered protection. As an additional aspect, digitizing unmarked farm roads allows us to enhance our understanding of farming patterns and practices along the river. Finally, digitizing tree lines shows areas that have a small degree of protection from erosion and bank destabilization, even though they lack the complete protection afforded by the more extensive riparian buffers. Tree lines, coupled with the land use/cover data collected, can be used to identify areas that need riparian protection, locations of degraded riparian areas, and areas that can readily be established as more complete riparian buffers.

Methods

See Methods in Historical Analysis Section.

Results/Analysis

Having created the land use/land cover analysis from the 2003 orthophoto of the study area, we were able to determine the area of land in each category. In total, the study area covered 5046 acres. Within this area, land used for agricultural purposes was by far the dominant type (Table 2, Figure 2). Specifically, cultivated land for crops such as hay and corn covered 1732 acres, which was 35% of the total land; land used for grazing purposes or abandoned fields comprised a total of 1729 acres, or 34% of the land. In total, 69% of the study area has a cover-type of field, including cultivated and uncultivated fields. Outside of the agricultural land uses, forest was found on 867 acres of the land. This constituted 17% of the total area. Partial woody cover encompassed 311 acres, or 6% of the land. Finally, the remaining 8% of the land, or 405 acres, was developed land. The majority of developed land was found at the northern tip of our study area, in the city of Vergennes.

Table 2: 2003 land use acreages in study area along Otter Creek

Category	Area in Acres
Forest	867.6
Cultivated	1729.1
Partial	311.9
Uncultivated	1732.7
Developed	405.3
Total	5046.7

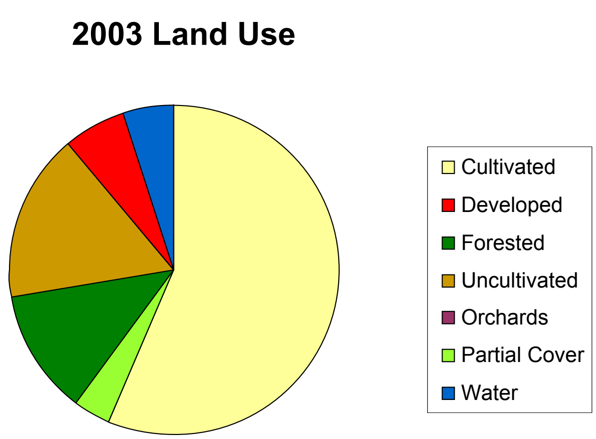

Figure 2: 2003 land uses in study area along Otter Creek

Otter Creek GIS Analysis and Assessment-

<u>Introduction</u>

The primary purpose of this GIS analysis is to establish possible options for a minimum zone of protection around the Otter Creek in the City of Vergennes, and Towns of Panton, and Waltham. Contained within this assessment are many static maps which are valuable for display and planning purposes, there is also a great deal of information which has not been specifically used but which may play an important role in the future assessment of this area.

The GIS analysis is meant to be a dynamic product which can be used pro-actively by the recipients for whatever assessment or planning purpose they may deem necessary. While baseline spatial parameters have been established for the analysis, such as watershed and roadway boundaries for this reach of the Creek, they are by no means the only ones that can be used.

What follows is a brief explanation of some of the steps taken to create the possible minimum zones of protection.

Data Collection

The primary source of data was the Vermont Center for Geographic Information (VCGI). The data that the Center possesses is generally collected on a statewide basis. VCGI is the definitive general public source of GIS data in Vermont. In addition to VCGI's resources, layers such as ownership parcels, zoning, and Federal Emergency Management Agency (FEMA) floodplains were obtained from the Addison County Regional Planning Commission's (ACRPC) GIS Data Manager, Kevin Behm. Bill Hegman of Middlebury College's Department of Geography provided several information layers not commonly available. The last major source of information was student-developed and used historical and current aerial- and orthophotography in order to digitize land-use types along the river reach of interest.

This information was then put into a common location, broken down by information type so as to provide an easily searchable framework in Arc programs.

Data Analysis

The primary basis for analysis was a digitized stretch of Otter Creek that was based on 2003 orthophotography. While the boundaries for the Creek as digitized are not consistent with what is portrayed in many of the other, previously available GIS layers, our digitization of the river channel

is the common denominator in all our analyses and we believe it to be the most accurate representation of the where the actual river-channel edges currently are.

We researched various types and sizes of riparian buffers and concluded that implementation of a buffer along this stretch would benefit river health. Research was then conducted on possible parameters that could be used in GIS and three sets of guidelines and one geomorphic feature were chosen as possibilities.

Once the actual values for riparian buffer width were determined, in distance from river's edge, ArcGIS was used to create a buffer around the digitized river polygon in accordance with the various buffer specifications. We then selected ownership parcels that abut the river (as those property owners would presumably be the most impacted by the implementation of a buffer of any type) and intersected their property parcels with the buffer. From this intersection, we could then determine the percentage and number of acres that would be affected in each parcel. Additionally, tax grand list information was collected from each town and joined with the intersected database file in order to query property owner information.

The FEMA floodplains layer was also intersected with ownership parcels. We then joined the tax grand list information to the new layer's attribute table as before.

In addition to establishing a minimum zone of protection map, we created several display/analysis maps that can be used for public meetings, planning, or assessment. They include maps of wetlands, conserved lands, flood-prone areas, and alluvial soils, as well as maps that show ownership parcel codes and past and present land use.

Description of Maps

Wetlands Map:

This map was created using a publicly available file describing the location of wetlands, overlaid on twenty-five foot contours that we generated, and displayed with the ownership parcels that abut the river. The spatial extent of this map is the boundary of the Otter Creek reach at this point in the river, derived from state-based watershed boundary data.

Conserved Land Map:

Conserved lands were displayed based on the Protection Level (PROTLEVEL), a nationally recognized system for cataloging protected or conserved lands developed by the U.S. Gap Analysis Program. A more complete definition of this system is provided on the map and can also be found in the GIS metadata. These features are overlain on a digital copy of a USGS 1:24k topographic map. Ownership parcels for the entirety of Vergennes, Waltham, and Panton are included. Roads are included for orientation purposes.

Flood-Prone Areas Map:

There are two basic units of analysis on this map: the first is soils data pertaining to flooding and water content of soil units, and the second is a map detailing the spatial extent of the 100-year floodplain as developed by FEMA. We chose to use a table developed by the Natural Resources Conservation Service, called the Top Twenty Attributes table. This table lists twenty of the most commonly used soils attributes and it contains fields related to susceptibility to flooding and the soil moisture parameters. We then selected soils in the FLOOD field with a rating of "frequent" or "occasional" and performed a graphic overlay on 25-foot contours that we created. Additionally, we selected for all soils in the HYDRIC field marked "Y" for the presence of hydric soils. For a more

detailed explanation, please see the text of the map itself or refer to the metadata for the top20_soils GIS data. Ownership parcels abutting the river were added to highlight areas where landowners may experience flooding or frequently "ponded" water and areas that may ultimately be goals for protection (such as vernal pools). Roads were added for orientation purposes.

The other map highlights the spatial extent of the FEMA floodplains. We developed this map for insurance and planning purposes and determined where these areas overlap with river-abutting ownership parcels. Twenty-five foot contours were generated for this map, and roads were added for orientation purposes. The two maps are displayed side-by-side to call to attention the possibility of discrepancies between the two floodways. In making decisions with regard to floodway protection, it may prove useful to consider both.

Alluvial Soils Map:

Alluvial soils serve as a possible corollary to the Flood-Prone Areas map. The alluvial soils, deposited by rivers and streams, are indicative of historic floodplains and also have high erodability. These data were overlaid on 25-foot contours that we created and displayed with river-abutting ownership parcels. Roads were added for orientation purposes.

Parcel Codes Map:

These maps serve as simple locators showing river-abutting parcels and their corresponding ownership codes which can be matched up with tax grand list information to obtain information about how to contact owners.

Past Land Use:

This map was created using a series of aerial photographs from 1942 and 1962. They were scanned in order to manipulate them digitally and turned into a mosaic using Adobe Illustrator. The resultant files were brought into ArcMap where they were geo-rectified and corrected for distortion. Using heads-up digitizing, we identified and delineated areas with like characteristics and populated an attribute table accordingly. The result is a series of polygon and poly-line features which can be selected and displayed according to land-use attributes. Additionally, calculations for area and length were performed to make comparisons between years in order to determine how the land use surrounding the Otter Creek has changed.

Present Land Use:

Using a the same process listed above, the National Agricultural Imagery Project's 2003 one meter resolution color orthophotograph was used to provide the basis for heads-up digitizing of land-use areas. This was done in order to compare the current land use with the past.

For a more specific description of each map in the MXD folder entitled "Final Maps," please see the Microsoft Excel document in the "READ ME" folder entitled MXD_layer_names. This Excel document lists all the projects contained in this GIS along with the date they were created and a brief description of what may be found there.

Establishing a Minimum Zone of Protection

In the interest of providing multiple options for both VRC and landowners, we chose to make four different zones of protection around the river with respect to riparian buffering. This was

done based on recommendations of various buffer sizes as well as the desire to create options that would coincide with landowners' prospective interest with respect to their land.

The following four sections detail minimum zone of protection criteria established by various agencies and organizations:

Agency of Natural Resources

Based on three defining characteristics listed in "Riparian Buffer Guidance" (McClain 2005), the section of Otter Creek under analysis was determined a Category 1 stream (Table 3).

Table 3. Buffer-defining characteristics, Riparian Buffer Guidance, Agency of Natural Resources.

Function	Category 1 Stream Characteristics	Category 2 Stream Characteristics
Channel Stability	Stable with small belt width and floodplain requirements	Stable with large belt width and floodplain requirements
Aquatic/Terrestrial habitats and natural communities	Category 2 features not present locally or in proximity	Site is a travel corridor and/or riparian dependent species have been identified and/or significant natural communities are present
Removal of Pollutants from Overland Flow	Low-to-moderate erodability of soils, slopes less than 10%	Highly erodable soils and slopes greater than 10%

Channel Stability: Category 2
Habitat: Category 1
Pollutant Removal: Category 1

Thus the overall recommendation based on these classifications is 50 feet.

The Center for Watershed Protection

A 120-foot buffer was delineated using the following criteria:

A) A stream system's forest buffer shall consist of a forested strip of land extending along both sides of a stream and its adjacent wetlands, floodplains or slopes. The forest buffer width shall be adjusted to include sensitive areas contiguous to the buffer, such as steep slopes or erodible soils,

where development or disturbance may adversely affect water quality, streams, wetlands, or other waterbodies.

B) The forest buffer shall begin at the edge of the stream bank of the active channel.

C) The required width for all forest buffers (i.e., the base width) shall be a minimum of 100 feet, with the requirement to expand the buffer depending on:

Stream Order: In third order and higher streams, add 20 feet to the base width.

Percent Slope: Forest buffer width shall be modified if there are steep slopes that are within close proximity to the stream and drain into the stream system. In those cases, the forest buffer width can be adjusted.

Several methods may be used to adjust buffer width for steep slopes. The following is an example:

Percent Slope	Width of Buffer
15%-17%	add 10 feet
18%-20%	add 30 feet
21%-23%	add 50 feet
24%-25%	add 60 feet

100-Year Floodplain: Forest buffers shall be extended to encompass the entire 100-year floodplain, as well as a minimum of 25 feet beyond the edge of the floodplain.

Wetlands or critical areas: When wetland or critical areas extend beyond the edge of the minimum buffer width, the buffer shall be adjusted so that it consists of the wetland extent, as well as a 25-foot zone extending beyond the wetland edge.

This study recommends a 70-foot riparian buffer. Because this section of Otter Creek is a third-order stream, the minimum 50-foot buffer required an additional 20 feet. Steep slopes were rare along this stretch of Otter Creek and were not considered. The requirements regarding floodplain and wetlands were not factored into this analysis in order to expedite the process of creating a simple, yet effective buffer that would also be economically and politically feasible for the

stakeholders concerned. While it was important to factor in the buffer requirements of floodplains and wetlands, it was not entirely possible for a variety of factors.

ANR Stream Geomorphic Assessment Corridor

The zone of protection developed is based on the idealized river corridor similar to that which ANR's Stream Geomorphic Assessment Tool would develop. The full, lengthy process of developing the geomorphic river corridor is currently underway, so the corridor used in our study is a simulation based on the SGAT Appendix E: River Corridor Delineation Process. The process was as follows:

A) A buffer 2.5 times the channel width was taken from the stream centerline. The centerline was determined using the Vermont Hydrography Dataset stream centerlines; the channel width was measured using remote tools in ArcGIS 9.0; and the stream polygon was manually digitized based on 2003 NAIP orthophotography. Channel width was determined to be 207 feet (based on remote measuring and a random sampling of 17 points along the length of the reach). Buffer width: 502 feet on both sides of the river.

B) 4.0x channel width from a meander centerline, created by connecting the crossover points to form a "straightened" version of the river's travel vector. Buffer width: 830 feet on both sides of the river.

C) These two buffers were then dissolved to form one shape to account for both stream meanders and potential river meander from the central travel vector of the waterway.

FEMA Floodplains

Federal Emergency Management Agency Floodplains, most commonly used for insurance and planning purposes, were obtained from the Addison County Regional Planning Commission. These floodplains represent the 100-year floodplain Implicit is the assumption that the risk of damage to property outside these areas is drastically reduced, while those areas within are at more risk.

Each of the four buffers detailed above were intersected with town parcels abutting the river. The area and percent of the parcel within each of the buffer options was calculated. This enables VRC to show these possible buffers to planning commissions and landowners. VRC can also accurately quantify the land affected for cost/benefit analysis. These data should only be used as a rough analysis and should not serve as a substitute for surveying.

Works Referenced and Cited, Establishing a Minimum Zone of Protection

McClain, E. 2005. Riparian Buffer Guidance. Vermont Agency of Natural Resources, Dept. of Environmental Conservation, Dept. of Fish and Wildlife and Dept. of Forests, Parks and Recreation. <http://www.anr.state.vt.us/site/html/buff/buffer-final-2005.pdf>

Buffer Model Ordinance. The Center for Watershed Protection <http://www.stormwatercenter.net/Model%20Ordinances/buffer_model_ordinance.htm>

Stream Geomorphic Assessment Handbook: Handbook Appendices: Appendix E: The River Corridor Delineation Process. <http://www.anr.state.vt.us/dec/waterq/rivers/docs/assessmenthandbooks/rv_apxecorridordef.pdf>

Kline, M., S. Pomeroy, S. Jaquith, E. Perkins and S. DiMattei. 2003. 1.0 Programmatic Quality Assurance Plan for Stream Geomorphic Assessment Protocols published July 30, 2003. Vermont Department of Environmental Conservation, Water Department Quality Division. <http://www.anr.state.vt.us/dec/waterq/rivers/docs/assessmenthandbooks/rv_sgaquappsigned.pdf>

Introduction to Geomorphic Assessment

Rivers are dynamic systems that are extremely vulnerable to both natural and human stressors. As fluvial geomorphology is the study of factors that shape the interaction between rivers and the lands that surround them, a Fluvial Geomorphology Assessment provides an ideal method for recognizing and identifying sources of river stressors. Once stressors are determined, we can utilize these factors in conjunction with land use, flooding and buffer information and criteria to better locate at-risk areas and properties vulnerable to changes in river level and sinuosity. Our partial geomorphic assessment of the study area entailed two phases. In Phase One we interviewed the town road Commissioners in Waltham, Panton, Vergennes, Weybridge and New Haven to identify areas of recent construction or potential concern. In Phase Two we followed the SGAT protocol of the Bed and Bank Windshield Survey which afforded us the opportunity to field-verify the GIS data and to gather GPS data to map various features.

Phase I: Road Commissioner Interviews

In order to assess the study area's current geomorphology, it was necessary to identify potential human-induced river stressors. At the recommendation of Professor Marc Lapin and Joyce Cameron, the Town Clerk of Vergennes, we decided to contact the Highway/Road Commissioners in Vergennes, Panton, Waltham, Weybridge and New Haven. We briefly interviewed each Road Commissioner and any others present at the garage at the time of our visit. In the interviews, we sought to determine what type of work has been done along Otter Creek in terms of channelization, bank armoring, bridge and dam building, and culvert construction and maintenance. We also asked whether or not, to their knowledge, the construction or other factors had induced problems with erosion, increased sediment load, bridge washouts and debris jams. After completing the main segment of the interview, we asked for any other pertinent information

about the river that they may have had. If the Road Commissioner pointed out any town-maintained sites that were physically vulnerable or had undergone recent construction, we visited the site to photograph and document any findings of interest or information that contradicted what we had been told. All interviews were conducted in person, with the exception of Francis Warner in Waltham, who was contacted by phone.

Interview findings

<u>Vergennes</u>

In Vergennes we met with road commissioner Carol Conner. While he had little to say about the Creek south of the hydroelectric dam that is in Vergennes' town center, he informed us of a potential future bank stabilization project that would stretch the half mile from Comfort Hill corner on MacDonough Street to the Job Corps building up the hill. This project will cost approximately 1.5 million dollars and it would be state and federally funded, but it likely will not begin for several years, as adequate funds have not yet been procured.

The project would involve rip-rapping and installing steel pilings. Mr. Conner explained that MacDonough Street is sinking, and the sidewalk running parallel to the road is separating in various sections as land slips downward (Figure 3). Two older privately-owned brick houses, within close proximity to the river edge have experienced significant amounts of flooding in the past ten to fifteen years, and at least one has required basement pumping. In walking MacDonough Street, it was observed that both houses and other riverside properties have installed stone, cement or wooden forms of private bank stabilization. Further up the road, where the bank is steeper and not developed, erosion is visible.

Figure 3. Erosion damage below the Vergennes dam results in road sinking and sidewalk separation on MacDonough St.

Panton

After our meeting in Vergennes we traveled to Panton and met with Road Commissioner Paul Bodington, who has been working for the Town of Panton for the last five years. While mainly responsible for replacing and maintaining culverts and ditching, the Town of Panton is responsible for one bridge crossing Otter Creek on Panton Road, which was replaced ten years ago. According to Mr. Bodington, floodwaters never flow over the bridge, although they have come within three inches of the bottom of the deck during previous floods. We were also told that the bridge did nothing to constrict or alter the natural river corridor. Examination of the bridge site revealed, however, that two spits of land had been constructed on either bank to accommodate a shorter bridge length, thereby funneling river volume through a bottleneck (Figure 4). We did not determine whether or not sedimentation was occurring upstream of the bridge or if erosion was occurring downstream of the bridge. Aside from the bridge area, all other riverside property in Panton is privately owned.

Figure 4. River constriction in Panton due to an undersized bridge.

Waltham

The town garage in Waltham is privately owned by Francis Warner, and there is no acting Road Commissioner. There are no bridges crossing Otter Creek in Waltham, and Mr. Warner informed us that all riverside property is privately owned.

Weybridge

In Weybridge we spoke with Road Commissioner Bob Cyr who stated that there have been no bank stabilization projects along the stretch of Otter Creek that runs through the town. He pointed us towards the twin bridges beneath the hydroelectric dam, but determining the degree to which the river corridor had been affected was difficult as there is a significantly wider water area above the dam. The Weybridge Town Garage also replaced the wood plank deck of the Huntington Bridge on Morgan Horse Farm Road two years ago. This bridge lays half in Weybridge and half in New Haven. Upon visiting the site we observed a back-swamp above the bridge that has been significantly altered by driveway construction. A wetland area about 20 yards in length and ten yards

in width had been bisected by a driveway heading up into the woods, through which a single small culvert flowed to connect the two sections that flow into the river.

Mr. Cyr mentioned that a more significant amount of work is being done on the Lemon Fair River, a major tributary to Otter Creek. There is often serious flooding at Prunier Road and the town recently replaced the bridge crossing the Lemon Fair where it flows into Otter Creek.

<u>New Haven</u>

We have not successfully contacted the Road Commissioner in New Haven, but we did talk to the VTRANS office. VTRANS is responsible for maintenance of the bridge spanning Otter Creek on Route 17 in New Haven. To their knowledge, there have been no real bank stabilization projects in the town, although the flood in 1998 resulted in a need to replace the bridge.

Phase 2: Bed and Bank Windshield Survey

<u>Methods</u>

Our Otter creek study area is a larger, low-gradient river segment, which allowed us to complete the windshield survey phase of our assessment by floating the river in canoes. The windshield survey was completed the afternoon of April 11, 2005. In the field, our class divided into six canoe groups equipped with GPS receivers and digital cameras. Each canoe was responsible for recording, photo documenting , and logging two feature types on either the right bank or on the left bank. Back in the lab GPS data were downloaded into a shapefile and an accompanying attribute table was created. Attributes for each GPS point location included a feature classification, area description, and photographic links where applicable.

This was an efficient way to visit the stream and understand bank dynamics in a relatively short period of time. We completed our Windshield Survey following the guidelines established in Step Seven of the SGAT protocol. Our evaluation considered Dominant Bed Form/ Material

(Section 7.1), Bank Erosion (Section 7.2), and Debris Jam Potential (7.3). Being in the field also provided the opportunity to ground-truth our GIS- derived land use/land cover data. In accordance with the parameters suggested in SGAT protocol Table 7.1, we considered grade controls, riparian buffers, groundwater inputs, flow regulation/water withdrawal, and channel and bank modification. We chose not to assess valley type and confinement, corridor encroachments, and sediment storage, as they were not applicable to our reach of the river. In addition to the SGAT parameters, we also documented places of high recreational value, wildlife habitats, and storm-water inputs during our survey.

Results

The data from the field display several important characteristics of the river including the bed material type, erosion extent, locations of debris jams, and areas where there has been bank stabilization. The GPS data collected provided locations of important habitats, significant wetlands, and areas with recreation potential. Points of water withdrawal and water input were also discovered.

The reach of river that we focused on measured 6.6 miles, and its dominant bed form and material can be classified under the SGAT standards as dune ripple. Sections of bank erosion along the reach (Figure 5) were added together to reveal a total length of bank erosion that measured 1.4 miles (right and left bank length is not duplicated where dual erosion occurs), or approximately 21% of the reach.

 

Figure 5. Erosion along the reach of interest.

Riparian buffers were measured and their widths estimated. The total length of riparian buffers covered 1.66 miles on the left bank and 3.47 miles on the right bank, 25% and 52.3% of the banks respectively.

Three areas of log and driftwood debris jams were mapped, two areas of private bank stabilization in Vergennes were described, and four possible indications of water withdrawal were noted (Figure 6).

Figure 6. Water withdrawal point along the reach of interest.

Thirty tributaries were counted and four wetland areas, three inlets, and two groundwater drainage sites were mapped. A few areas of recreation potential were also recognized (Figure 7). With

several animals sited during our survey, including otters, birds, beavers, and muskrats, the habitat importance of the area is equally significant.

Figure 7. Duck hunting blind: recreation potential along the reach of interest

Discussion

Collected data and buffer analysis have indicated that implementation of a buffer would benefit the Otter Creek's health and its surrounding environment. The Windshield Survey and Road Commissioner interviews revealed that the Creek's conditions can be improved at certain point locations, as human-made structures and channelization have restricted river flow and caused erosion. Agricultural land abuts the water's edge in some places, leaving the Creek susceptible to environmental degradation due to agricultural runoff and accelerated erosion. Where development has encroached close upon the river corridor, infrastructure is deteriorating, as witnessed in Vergennes. Implementation of a buffer could not only alleviate some of these stresses, but it could also potentially mitigate the need for the extensive bank stabilization project that is in Vergennes' near future. Further degradation could be prevented as rip-rapping and installing steel pilings could injure the riparian environment more than it helps it.

Part IV. Buffer Implementation Feasibility Assessment

Landowner Outreach

Methods

In order to begin evaluating the potential for implementing a buffer, we established contact with each of the landowners along our study area of the Otter Creek. In conjunction with the Otter Creek Natural Resources Conservation District (NRCD), we contacted all 78 landowners via an introductory letter, which introduced both the Vermont River Conservancy and the Environmental Studies senior seminar project. A copy of this letter, which was composed by Pam Stefanek of the NRCD, can be found in Appendix1.

After sending the letter of introduction, we began calling the landowners. At least two call attempts were made to each landowner. From these calls, we were able to interview 24 individuals, which is approximately 30% of the total landowners. In the phone survey, we asked questions about three broad categories. These included land use, values, and conservation. With respect to land use, we asked about agricultural practices on the land, which included crops grown, harvesting frequency, and crop rotation. We asked whether cattle or other animals were raised on the land. For those landowners with livestock, we asked about water sources and manure storage facilities. With respect to values, we first asked about the landowners' opinion of the health of the creek and the area alongside the creek. Next we asked about family use of the river. Then we asked about the importance of protection of both the creek and the area alongside the creek. Lastly, we asked how a riparian buffer could change land values, how willing the landowner would be to create a conservation buffer, and how that willingness might change if neighboring landowners were doing the same. With respect to conservation, we asked whether the landowner has been involved in any conservation programs and if so which ones. Next we asked if any federal or state money had ever

been awarded to them as a part of a conservation program. Following this we asked about their knowledge of government and land trust programs. Last, we asked about previous applications or involvement with officials from NRCS, FSA, or land trust organizations. A copy of the survey itself can be found in Appendix 7.

Results

From our survey questions about land use, we found that 15 of the 24 landowners surveyed use their land predominantly for residential purposes. Of these 15 landowners, two also have a garden on their property. The other nine landowners actively use their land for agricultural purposes. Of these nine, four grow hay, three grow hay and corn, one grows corn, and one grows a variety of vegetables. Only two of the 24 landowners raised cattle. Of these, one allowed all cattle to graze down to the river while the other allowed only the young cattle to graze down to the river rather than the whole herd, as a means of saving money. The former did not have a manure storage tank, but the latter did have a manure pit, which was constructed in part with external funding. Concerning herbicide and fertilizer use, two said that they use herbicide on their corn and three landowners said that they use chemical fertilizer. Lastly, two landowners said that they had worked towards erosion control. One of these landowners did so 30 years ago. The other filled in dirt and rocks in the past year.

From the survey questions about values, we found that 10 of the 24 landowners think that the water quality of the river is acceptable whereas another 10 of the 24 landowners think that the water quality is not clean or needs improvement. The remaining four said that they were not sure. Concerning the health of the areas alongside the river, most landowners gave descriptions of the areas on their land about the vegetation and wildlife. Most people spoke about it seeming healthy otherwise they replied by saying they didn't know. In the words of one landowner, the area alongside Otter Creek is "friendly to bird and beast." Almost all of the landowners said that they

use the river. The most common activities included canoeing (7 respondents), nature viewing (6), and boating (4). Others included kayaking (3), fishing (3), irrigation (1), and skiing (1). The questions we asked about the importance of water-quality protection and habitat protection indicated a very high interest level in these matters. When asked to rank water quality protection on a scale of unimportant, important or very important, no landowners responded with unimportant. Only two said important and the 22 said very important. Similar results were obtained from the question about habitat protection. No landowners said unimportant, four said important and 18 said very important.

We also asked three questions regarding landowner response to the implementation of a buffer. The first question was for the landowner to evaluate how a buffer would change the monetary value of the land. Three landowners said that they already have a buffer on their property. Four landowners indicated that there would be no change in value at all with the addition of a buffer. Another four said it would increase the value, and an additional two said it would increase the value a little. Four more said that they did not know how it would affect the value. Only one landowner said that it would be a financial detriment, due to the limitation of cattle accessing the river for water. In terms of landowner willingness to create a buffer, six landowners said that they would be willing to create a buffer on their land and an additional two landowners said they would if the economics suited or if it were free. Equally, eight landowners said that they would not be willing to create a buffer on their land. When asked whether a neighbor's participation in buffer creation would affect their willingness to do so, four landowners said yes, three said no, and five said possibly. The others said that it did not matter or that they already had a buffer on their land.

From the survey questions about conservation, we found that only one of the 24 landowners stated any involvement with conservation programs. Our results thus indicate that outreach and education about these programs is extremely important and have great potential to yield results

beneficial to conservation. It is hoped that the initial contact with these landowners will be followed up with work to implement riparian buffers where landowners are willing.

Conservation Easements

As farm practices, population shifts, urban sprawl and other contributors to non-point pollution are affecting river quality, citizens, conservation groups and non-profits organizations are searching for best-practice methods to minimize detrimental effects to the health of rivers. Arguably, one of the most prominent answers to these problems is the implementation of conservation easements. A conservation easement is a voluntary legal agreement between a landowner, and, usually, the state or a non-profit organization in which the landowner agrees to control development in the interest of land conservation. Not only can conservation easements provide land protection, but, in addition, some can further provide area set aside for light public recreation. A conservation easement on land near a river can have many positive effects on the riparian habitat, river systems, aesthetics and the local community. Conservation easements are a critical tool to protect private lands across the United States permanently.

In addition to many farmers' desires to help conserve land, water, and habitat, conservation easements are popular among farmers for two main reasons, i) direct economic incentives and ii) tax incentives for the landowner as compensation for conservation. In 1997, Congress established section 2031(c) of the Federal Tax Code, which provides that estate tax benefits may be available in association with a qualified conservation easement. This law can permit an exemption of upwards to 40 percent of the value of the land subject to a conservation easement, provided that several qualifications are met (Draper 2004). Another form of monetary gains associated with conservation easements is the entire amount acquired by simply selling the development rights to a land trust or

governmental agency. Agencies or land trusts have programs that compensate farmers equitably for the restricted land value given up by the conservation easement.

There are some minor problems associated with conservation easements in the United States. The Uniform Conservation Easement Act (UCEA) which was drafted by the National Conference of Commissioners on Uniform State Laws (which approves and recommends enactment in all states), states that conservation easements can be terminated just as any other easements can. Whether, this is the case in Vermont, remains to be clarified, but there are many policy concerns that could impinge upon previously established conservation easements. Eminent domain is the process by which the government flexes its muscle and transfers property over to itself for public purposes (i.e., roads, telecommunications, water supply, public buildings, etc.). While this is not likely to happen along Otter Creek any time soon, it is important to note this in the tailoring of the easement to prevent any future conflicts. One way to counteract something like this is to donate the conservation easement to another governmental agency before the land is taken. For example, donating the land to US Fish and Wildlife has and can prevent the land from being developed by government through its power of eminent domain (Draper 2004).

Another problem is abandonment, in which case the trust that monitors the conservation easement dissolves and does not transfer the easement over to another agency. This can result in the loss of the conservation easement in general. This is easily remedied, by ensuring that there is a "third-party right of enforcement" in the legal documentation that enables another party to enforce and monitor the easement even though they are not the true "holder" (Draper 2004).

There is also the issue of an increase in the land value, in which a landowner may attempt to reverse conservation easements because of incentives for large monetary gain as a result of selling the property to developers. It is the responsibility of the easement holder to ensure that a landowner is not permitted to do so by detailing the conditions clearly. Furthermore, some

conservation easements, as is the case in Alabama, automatically terminate after a certain amount of time, thereby voiding any restrictions held on the land. This is not the case in Vermont, but once again, this must be laid out clearly in legal documentation. Even audits by the IRS have posed problems for some farmers trying to claim different appraisal values. Usually landowners win these in court, but at a significant loss of money and time. Fortunately, "automatically terminating" conservation easements are becoming less and less common throughout the country (Draper 2004). The problems mentioned above are often easily avoided through careful planning and wording.

Conservation easements in Vermont can be facilitated and aided by working in conjunction with a program such as the Conservation Reserve Enhancement Program (CREP) where applicable. CREP delivers payments by the acre and currently has ample funds to compensate farmers. The one important factor that conservation easements have over programs such as CREP is permanency. Conservation easements protect property forever, and in a world that is under increasing land-use conflicts, pollutants, diminishing river systems, and varying land value over time, a permanent solution should be put into action. Those trusts that implement conservation easements can form productive partnerships with CREP, and will likely find common ground on which all interested parties can help to advance conservation.

Otter Creek: A Local Conservation Easement

The Lake Champlain Land Trust (LCLT) has provided us with a copy of a conservation easement that they were donated on the Lower Otter Creek in 2001. The area, in Ferrisburgh, Addison County, is just north of Vergennes and consists of one acre of undeveloped land that provides wildlife habitat along the river. It also is adjacent to the Lower Otter Creek Wildlife Management Area. The legal agreement by the landowner and the private land trust entails six main components of the contract that are to be adhered by. These consist of:

i) Purposes of the Grant and Management Plan

ii) Restricted Uses of Protected Property

iii) Permitted Uses of the Protected Property

iv) Public Access

v) Enforcement of the Restrictions

vi) Miscellaneous Provisions

The land is still owned by the original owner and he or she is free to do anything they want with their property with the exception of what is recorded in the easement. In this particular case, the purpose of the grant was for habitat protection, low-impact pedestrian public outdoor recreation and to protect water quality in Lake Champlain and Otter Creek. Specifically, the contract noted that the area:

a) Protects Lake Champlain's water quality by conserving its watershed; and

b) Protects 400 feet of frontage on the Otter Creek from unwise development; and

c) Protects seasonally flooded forest habitat critical to certain flora and fauna; and

d) Is highly visible and of scenic value to the many recreationists using Otter Creek

The area not only protects habitat and water quality, but is also publicly available for the low-impact use of the public and offers scenic value to recreationists. There also has to be some form of a management plan that includes the objectives and purposes of the grant.

Restrictions and permitted uses are also important in ensuring the purposes of the conservation easement are met. In this case, no structures are to be erected, but some reasonable signs that enhance the educational or directional use of the land may be placed. More pertinent to our study, there is no manipulation of natural watercourses or activities that could be detrimental to the quality of the water or alter the natural water level or flow. The uses of the land are for conservation and non-motorized recreation, so maintaining public trails is permissible. It is even permissible for the owners of the land to charge public fees during community events held on the

property, as long as the fees are reasonable for maintaining the area in accordance with the purposes of the conservation easement. Public access is only available if it does not conflict with the conservation goals.

Easements are useless without enforcement, and the easement holder must make consistent and reasonable attempts to ensure that the restrictions and permitted uses of the land are followed. In the event that such requirements are not met, it is the duty of the land trust to inform the landowner of the infractions and if necessary, take legal action in order to enforce the improvement of the land at the expense of the landowner.

This model conservation easement is especially important to our study because it concerns land several miles north along the Otter Creek from our study region. We have outlined many important factors in the document; and there are other elements that could be of pertinent value that can be seen in the appendix (see Appendices 2-4). Conservation easements that not only affect land use and habitat, but water quality and riparian areas are of twice the ecological importance. By having this model as a sample legal agreement, it has broadened our understanding of conservation easements and their complexities and most importantly, it gives us the language and purposes that reflect the conservation sentiments of Addison County, the Lake Champlain watershed and Vermont.

Riparian Buffer Conservation Easements: Ordinances and Conservation Approaches

Although many different criteria are used to decide the size of a buffer, most conservation organizations favor a small buffer over the possibility of not establishing a buffer at all. Furthermore, in accepting or purchasing a conservation easement the land trust almost always would rather see the land remain as open space without a buffer than be developed; alternatively, if they were to require a buffer, landowners not willing to establish one on their property may decide not to legally conserve the land at all.

The ordinances that are used to establish buffers range in complexity from a basic establishment of a 50-foot buffer, to criteria that use slope, geological composition, runoff sources, local industry, and the location of hazardous waste in calculating a buffer that protects aquatic ecosystems to varying degrees. The Center for Watershed Protection has produced an all encompassing buffer ordinance that uses many of these criteria (Appendix 2).

Few, if any organizations require riparian buffers in establishing conservation easements, as they would rather acquire the development rights of the property without a buffer than have the land developed. In our research we did not come across any land trusts that explicitly state that they only accept conservation easements along rivers that contain buffers.

In addition, many conservation organizations do not require minimum buffer width because often, a buffer establishment of 20 feet is enough to prevent some soil erosion (Westing), and although it accomplishes little in the way of reducing runoff, it is preferred to allowing the streambank erosion to occur without a buffer. Even the planting of a 5-foot buffer that stabilizes the streambank is preferable to the continuation of streambank erosion in some areas. However, in investing money in a buffer restoration project, a few organizations require minimum buffer widths to be established. Essentially, they feel that if they are to allocate the resources towards a buffer restoration project, they want to ensure that it is effective in benefiting the riparian and aquatic areas of the water body that they are protecting, and that it is consistent with the goals of their conservation project.

One example of such a program is the Chesapeake Bay Initiative. This program, a collaborative effort between Ducks Unlimited and the Chesapeake Bay Foundation, requires a buffer of at least 100 feet in width in order to enroll. In addition, the buffer must be planted with trees. Natural grass-planted areas do not count towards the buffer, as they are not as effective in buffering aquatic ecosystems from runoff. Although this criterion may seem rather demanding of

those who are willing to sign a conservation easement on their land, the Chesapeake Bay Initiative provides significant funding beyond federal and state programs. The co-payment program that they have created is a noteworthy use of federal, state, and local conservation organization resources in order to accomplish the common goal of establishing a riparian buffer conservation easement.

The Chesapeake Bay Initiative combines an additional 25 percent cost-share reimbursement with the 75 percent cost-share available through the CREP program, and thus pays the complete cost of buffer installation. The co-payment plan covers the cost of trees and tree planting, fencing, alternative water sources, and many other costs associated with wetland protection (Virginia Department of Recreation and Conservation).

A riparian buffer conservation easement is a term that is used to describe many different types of easement arrangements. The Franklin Soil and Water Conservation District in Franklin County, Ohio has created a set of buffer easements that range in the length and width of the buffer, as well as the amount of time that the easement must remain in effect. Although this organization provides greater compensation for buffers that are wider, longer, and where the easement remains in perpetuity, they also do provide easements for landowners who may not be willing to place their land in a permanent easement.

For landowners willing to voluntarily establish a 50-foot buffer alongside the river, they finance 75% of all project costs independently in a 15-year conservation lease. For landowners willing to establish a 120- to 300-foot buffer the FSWCD finances 75% of the cost along with a 25% bonus from the Darby Creek Association, a conservation organization similar to VRC (Appendix 4). This temporary agreement is transferable as the property changes hands, but as soon as the length of the lease expires the development rights are returned to the owner. This agreement is particularly attractive to landowners who would like to establish a buffer, but see their property as an investment that will have a decreased value if their development rights are sold. This agreement allows the

landowner to protect the river in the short term, but not to affect their bottom line if they decide to sell their property in 15 years from the time of the conservation lease. Although clearly not all buffers that are established under a conservation lease will be returned to grass or cropland after 15 years, the expiration of the lease does give the landowner the right to completely clear cut the established buffer.

For landowners willing to establish a riparian buffer by placing their land in conservation in perpetuity, minimum lengths and widths are required, each with their own set of financial benefits in the establishment of a "conservation deed." A conservation deed changes hands as the title of the property changes hands and is permanent. Financial benefits include the cost of the project (as covered in previous outlined agreements) with additional benefits such as: an allowance to seek advice from a tax/real estate advisor, 100% financial assistance for appraisal, survey, title, and closing costs, and potential federal, local, and real estate tax benefits based on appraised easement value (Appendix 4).

One of the most effective ways for a conservation organization to protect stream quality is through cost-sharing. Through its embrace-a-stream program, Trout Unlimited provides funding with no minimum width requirement or acreage requirement. Trout Unlimited has the specific goal through this project of providing matching funds, which in combination with state or federal funds, meet the full cost of the project. In order to make better use of their resources, the embrace-a-stream program specifically seeks out landowners who are already receiving, or are eligible to receive public financing, thereby making these options more attractive through cost-sharing. The program also provides funds for research and education, something that may help to generate local support for their projects.

Local conservation organizations can make significant changes using monetary resources to finance riparian buffer conservation easements, especially if they are sharing the cost with a federal

or state program. Other great accomplishments have come in the realm of providing expertise, local knowledge, encouragement to landowners, and assistance with monitor established buffers. Cost-sharing combined with encouragement is one way that a local conservation organization such as the Vermont River Conservancy can liaise between landowners and the sometimes confusing federal and state programs that finance riparian buffer conservation easements.

Introduction to Federal and State Programs

Implementing a buffer along this section of the Otter Creek which runs directly into Lake Champlain is an important step to benefit the overall health of the aquatic ecosystems. The funds available to acquire private lands for riparian buffers are limited, but because of buffers' important job of intercepting and sequestering pollutant runoff, the federal government, municipal governments, private land trusts and others can establish riparian buffers through many means. They can make a fee-simple purchase of riparian parcels or purchase easements that restrict land use along the riparian edge of a larger parcel, or they can provide incentives to set up riparian buffers on their own (Azzaino et al., 2002). The large state and federal incentives programs for buffers deserve serious attention because they control a great deal of money that is available for large conservation projects.

The Conservation Reserve Program (CRP) is the largest government program providing technical and financial assistance to eligible farmers and ranchers to address natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as grasses (native or otherwise), wildlife plantings, trees, filterstrips, or riparian buffers. Farmers receive an annual rental payment and assistance in setting up the various conservation practices (50% cost-share) (www.environmentaldefense.org).

The Conservation Reserve Enhancement Program (CREP), another voluntary program for agricultural landowners, is an offspring of the Conservation Reserve Program. CREP is a unique state and federal partnership that allows landowners to receive incentive payments for installing specific conservation practices. Through CREP, farmers can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible land as well as the incentive payments already mentioned. The term of CREP contracts are generally 15 years, and breaking the contract would not be rational because of the high penalties including repayment of all rental, incentive, and cost-share payments, as well as any punitive fines imposed by the USDA (Lynch and Brown, 2000). Table 4 shows the number of CREP contracts currently enacted in Vermont, accounting for around 943 acres at an average rental payment of almost $90/acre on those contracts.

Table 4. CRP Enrollment, March 2004 (CREP only). Source: http://agriculture.senate.gov/Hearings/fsaCSPstats.pdf

STATE 1/	NUMBER OF CONTRACTS	NUMBER OF FARMS	ACRES	ANNUAL RENTAL ($1,000)	PAYMENTS ($/ACRE)
VERMONT	77	62	943	85	89.65

We have had the fortunate opportunity to learn more about CREP through Laura Hanrahan, the state coordinator for CREP programs. She has provided us with valuable information. In the State of Vermont CREP is paid through a 20% state cost share in which the federal government pays for the other 80%. Currently, the State of Vermont has an annual budget of approximately $1,000,000 for CREP. CREP, unlike CRP or other conservation programs, provides a 90% cost share for the implementation of the buffer as well as an annual land payment. Often the U.S. Fish and Wildlife Service will provide the extra 10% to develop the riparian buffer, or perhaps the VRC or another land trust could further subsidize the implementation costs.

To become eligible for CREP land must be in agricultural use and next to a river. The program pays its rental payments based on the soil type. Craig Miner of the Farm Service Agency (FSA) has provided us with an average figure in the Vergennes area. Ninety percent of the soil farmed on is Vergennes clay, and payments range from $10/ year to $137/ year (marginal pastureland to frequently rotated cropland). The incentive payments for then planting buffers can be anywhere from an additional 50-70% of the rental payments. This program is run through the FSA, and in Addison County Craig Miner is in charge of all the CREP applications. The FSA at the local level decides if the landowner is applicable and then sends the application to the state level to obtain funding from the state and federal levels. Important things to note about CREP are that it does not preclude the landowner from selling the property and the land under contract is not exempted from state land taxes (Craig Miner, personal communication).

Other programs run by the state and federal government include EQIP, WHIP, and WRP, which are described below.

The Environmental Quality Incentives Program (EQIP) promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible farmers and ranchers install or implement structural and management practices on eligible agricultural land.

"EQIP offers contracts with a minimum term that ends one year after the implementation of the last scheduled practices and a maximum term of ten years. These contracts provide incentive payments and cost-shares to implement conservation practices. Persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. EQIP activities are carried out according to an environmental quality incentives program plan of operations developed in conjunction with the producer that identifies the appropriate conservation

practice or practices to address the resource concerns. The practices are subject to NRCS technical standards adapted for local conditions. The local conservation district approves the plan.
EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive. However, limited resource producers and beginning farmers and ranchers may be eligible for cost-shares up to 90 percent. Farmers and ranchers may elect to use a certified third-party provider for technical assistance. An individual or entity may not receive, directly or indirectly, cost-share or incentive payments that, in the aggregate, exceed $450,000 for all EQIP contracts entered during the term of the Farm Bill" (NRCS, 2005).

"WHIP, the Wildlife Habitat Incentives Program, is a voluntary program for people who want to develop and improve wildlife habitat primarily on private land. Through WHIP, USDA's Natural Resources Conservation Service provides both technical assistance and up to 75 percent cost-share assistance to establish and improve fish and wildlife habitat. WHIP agreements between NRCS and the participant generally last from 5 to 10 years from the date the agreement is signed."

"WHIP has proven to be a highly effective and widely accepted program across the country. By targeting wildlife habitat projects on all lands and aquatic areas, WHIP provides assistance to conservation minded landowners who are unable to meet the specific eligibility requirements of other USDA conservation programs. The Farm Security and Rural Investment Act of 2002 reauthorized WHIP as a voluntary approach to improving wildlife habitat in our Nation. Program administration of WHIP is provided under the Natural Resources Conservation Service" (NRCS, 2005).

"WRP, the Wetlands Reserve Program is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The USDA Natural Resources Conservation Service (NRCS) provides technical and financial support to help

landowners with their wetland restoration efforts. The NRCS goal is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection" (NRCS, 2005). WRP, unlike the other previously described programs is an easement program, offering three different types of enrollment: a permanent easement in which the farmer sells the rights to the land for a negotiated price/current value, a 30 year easement in which farmer receives 75% of the full easement payment, or a restoration cost-share agreement (NRCS, 2005). For further information on any or all of these programs, the NRCS website (http://www.nrcs.usda.gov/programs/) has a wealth of information.

Introduction to Economic Analyses

It is important to understand the economic costs and benefits of implementing buffers. Given limited resources, we must decide how we can most efficiently distribute those resources, and cost-benefit analyses allow us to do this. By no means, however, should this efficiency approach be the only criterion for decision making. When making policy decisions it is sometimes necessary to use some kind of safety standard that makes sure no one is put at risk by taking the most efficient route. In order to maintain a certain level of health within society it is sometimes necessary to use resources in a manner that is not the most cost-effective, but rather to give up something of a greater monetary value for some minimum level of environmental or public health. Society could also choose to use their resources in a sustainable manner, treating the economy, and the environment as one, and not taking anything away for our and future generations benefits, but not reaping what the earth sows in a fashion that deteriorates its natural resources. While it is easy to conduct cost-benefit analysis on such things as the addition of an extra gas pump at a gas station, it is much harder when dealing with a public good, such as a river, and the private practices of those

living along the river. Thus, it can be difficult to account for the many intangible costs and benefits of implementing a conservation buffer.

Conservation practices along rivers and streams in agricultural watersheds depend on private landowners' decisions about how they manage their land. Adding a riparian buffer can minimize agricultural impacts on nearby rivers and streams, thereby benefiting all of society, yet it may not be the best thing for the farmer personally. However, management along the riparian zone is critical for maintaining ecological health, for riparian zones filter, transform, and absorb agricultural nutrient runoff to improve water quality (Lynch and Brown, 2000). Therefore, some balance must be struck.

In our analysis we will look at the creation of buffers from both a society-as-a-whole point of view, and the individual farmer's point of view in order to determine whether implementing a buffer, and putting the productive land along the river out of use is appropriate according to an efficiency standpoint. We do this because of the dual nature of rivers, affecting society as a whole but at the same time running through an individual property owner's land. In the end it needs to be a worthwhile investment for society to spend its money on making it worth individual landowner's while to set aside their land.

A cost-benefit for society as a whole is not appropriate on its own, since individual property owners are the decision-makers for their lands. Since the landowners ultimately have to make the decisions, it is appropriate that we understand their incentives to create buffers. Researchers have found that the adoption of conservation practices is not solely based on extrinsic economic incentives, but rather individuals are generally influenced by a range of social pressures and intrinsic motivation. Nonetheless, a convincing argument includes the possibility for economic incentives as well as easement possibilities to accommodate a broad range of landowners' philosophies. Conservation practices occur over a broad range of programs, land trusts, and easements, and so we must also look at these different programs in our analysis as well.

Costs and Benefits to Society

In order to determine if the implementation of a buffer is economically beneficial for the community we present a cost-benefit analysis. The cost-benefit framework involves the application of economic methods to measure the contribution that any public action or policy will make to the economic well-being of the society. It involves the estimation of the gains and losses to all affected individuals, in dollars, and the aggregation of these costs and benefits across people and across time. This cost-benefit test passes if the net present value of including the buffer is greater than the value of letting the land remain in its current state.

We have found that that the benefits of buffers in terms of their contingent valuation are much greater than the relative costs associated with taking that land out of production. This shows us that it is beneficial for society to offer incentives for farmers and other individuals who ultimately make the decisions about what to do regarding riparian buffers on their land.

Value of Ecosystem Services

Valuation of ecosystem services is controversial because of the potential importance such values may have in influencing public opinion and policy decisions. Failure to quantify ecosystem values because of the difficulty in quantifying dollar numbers for deeply held ethical beliefs has resulted in a value of zero being placed on ecosystem services. In most cases, however, ecosystem values are much greater than zero (Daily 1997 cited in Loomis et al. 2000).

Rivers can provide many services to humans, and these have occasionally been valued by economists (Table 5). Economic theory does not restrict the concept of value to direct consumption by humans (use value); non-use values also exist. Any resource that is independent of a person's current consumption of an environmental resource is termed non-use. For instance, individuals can

value the mere presence of a clean, well-protected river or a riparian buffer even if they do not make use of that resource (Loomis et al. 2000).

Use benefits that can be improved by implementing and conserving riparian buffers include in-stream recreational benefits such as fishing, swimming, canoeing, and kayaking. A second use category is aesthetic and ecosystem improvements; these include near-water recreation (hiking, picnicking, and photography) as well as wildlife-viewing and hunting. When considering non-use values of a riparian buffer one must consider the stewardship of the land, vicarious consumption by nearby citizens, value of intact ecosystems, and the bequest values for future generations. Beyond the use and non-use values of the river itself, riparian buffers and improved habitat will inevitably have an effect on the value of the land itself (Wilson and Carpenter 1999).

As values like fish habitat and recreation value are not priced, water managers are faced with a huge challenge of balancing the unknown with distinct agricultural, municipal, and industrial values. In this study we are presented with a challenge of determining proximate values for the ecosystem services Otter Creek provides to the residents in this area and how these will be improved with the implementation of a riparian buffer. The benefits of improved water and wildlife habitat quality are for the entire community while the costs rest in a handful of landowners beside the river.

In environmental economics, ecosystem values are often measured by finding a contingent value for the services. This process involves correspondents indicating their willingness to pay for the ecosystem services. Although we were unable to quantify a true willingness to pay from landowners we were able to get a sense of the importance of the creek's protection. No one considered the protection of the creek's water or the habitat along side the creek to be unimportant and the vast majority considered it very important to them. Furthermore, questions asked about activities along the river confirmed our belief that people alongside the river did use and enjoyed the river's natural recreation.

In order go beyond our vague concept of contingent value we examine a cross section of values for freshwater ecosystem services in the economic literature (Table 5). Economic studies show a wide range of recreation, use, fisheries, and ecosystem service values. The studies use a variety of cost-approximation methods including travel cost method, hedonic pricing, and contingent value method (Wilson and Carpenter 1999). The contingent value studies give an approximation for yearly values per resident. For a 45 mile stretch of river in Colorado, residents

Table 5. Value of ecosystem services.

Valuation method	Study and publication data	Freshwater ecosystem type	Good(s) being valued	Sample units	Unit-specific benefit (1997 $)	Aggregate benefits (1997 $)
TCM (travel cost method)	Young and Shortle (1989)	Lake	Recreational benefits associated with water quality improvements in St. Albans Bay, Vermont	All recreationits on St. Albans Bay, Lake Champlain	NA	Aggregate per season $599,000
HP (hedonic pricing)	Young and Shortle (1989)	Lake	Aggregate increase in property values associated with specified water quality improvements in St. Albans Bay, Vermont	All Households located in the vicinity of St. Albans Bay, Vermont	NA	Increase in property values St. Albans Bay, $18,000,000
CVM (contingent valuation method)	Berrens et al. (1996)	River	Benefits of maintaining minimum in stream flows in one New Mexico River (Middle Rio Grande) vs. all New Mexico rivers	All households in the state of New Mexico	Middle Rio Grande River, $29; all New Mexico rivers, $91	NA
CVM	Desvouges et al. (1987)	River	Mean WTP for improved access to river with improved water quality	River users and nonusers from five-county area around Monon-gahela River	Users, $139; nonusers, $49	NA
CVM	Loomis et al. (2000)	River	Five ecosystem services: dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation.	Sample of households nearby or along portions of the La Platte River	$21 per month or $252 annually.	$19,000,000-$70,000,000
CVM	Sutherland and Walsh (1985)	River	Protection of water quality in the Flathead River drainage system, Montana	Resident households within 676 km (420 miles) of drainage	Flathead basin residents WTP, $113	Total value for border states and Canada $160,000,000
TCM	Smith and Desvouges (1986) and Smith et al. (1986)	Reservoir and river	Boatable to swimable waters	Households along the Monangahela River Basin	Annual benefit per household:(1) loss of boatable, $6 (2) boat to fish, $13 (3) boat to swim, $51	NA

were willing to pay $252 per year for ecosystem services in rivers measured by 5 services (dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation) (Loomis et al. 2000). In New Mexico, all households were willing to pay between $29-91 per year to increase the "naturalness" of the Rio Grande (Barrens et al. 1999). For the protection of

the Flathead River drainage system in Montana, residents within 420 miles of the drainage were willing to pay $113 (Sutherland and Walsh 1985).

Canoeing and kayaking were valued at $16.85 per day, and the existence of a riparian buffer would serve to increase the scenic quality and water quality of the river hence improving recreation (Freeman 1995). The aggregate of recreation benefits associated with water quality improvements in St. Albans Bay, Vermont were $599,000 per season (Young and Shortle 1989, cited in Wilson and Carpenter 1999). Countless studies have proclaimed riparian buffers as beneficial to fisheries and other wildlife. Anglers in Maine valued each individual fishing experience from $11.85-$18.11 (Freeman 1995).

The value of riverfront property along Otter Creek and the surrounding neighborhood would likely increase if buffers were established and conserved. Improvements in water quality increased riverfront and nearby property values in a number of hedonic pricing studies. A local example of water quality improvements in St. Albans Bay (from decreased agricultural runoff) showed that aggregate increase in property values of all households located in the vicinity of St. Albans was $18,000,000 (Young and Shortle 1989).

The literature shows a clear value for freshwater ecosystem services; the value of improved water quality, value of recreation, and the increase in land values show how much people value the improvements in land and water quality. Our conversations with landowners afford a local perspective on these pricing methods and although we cannot quantify the values of the ecosystem services we state that the intangibles do have a distinct value to society as a whole.

Current value of land use included in buffer

Now that we have a good idea of the benefits of creating a buffer along this riparian corridor (potentially on the order of the tens of millions of dollars over the next 30 years), we must look at

the costs associated with buffer creation and conservation. From the GIS analyses we obtained the total land area that would be affected by the various buffer options, and so can discuss the value of the total yield of that land that would be taken out of agricultural production (Cultivated, Un-cultivated, and Partial) for a buffer and the associated cost of putting in the buffer.

We estimate the value of land taken out of production in terms of hay yield.[1] Since we do not know exactly what each farmer produces, and some of the land is not even used for agriculture which we know from our float trip, using a single crop as an estimation for what is produced in the relevant areas is problematic, but it can at least give you an idea of the production value of the land per year. Hay yields on average 2.75 tons per acre, and fetches a price of around $110 per ton, for a total value of $303/acre, and we also found out that it costs about $300 up front to put in a grass buffer and $1,500 to put in a forest buffer (Craig Miner, personal communication). Running these values out for 30 years, including a 1% growth rate on the yield of hay, and using a 4% discount rate to take into account the fact that a dollar today is not worth as much in the future we get present values of the costs to society of putting in the 3 different buffers (Table 6).

Table 6. Present value of implementation and foregone crop costs over a 30-year period. (Based on 2001 yields of all hay in Vermont of $303/acre assuming a 1% growth rate over the next 30 years. The total acres affected is a combination of the un-cultivated, cultivated, and partial land-uses. We assume that half of the area will be put into a grass buffer and half into a forest buffer, at a cost of $300 to seed down the land for grass, and $1,500 to implement a forest buffer. A discount rate of 4% was used in calculating the Net Present Value (New England Agricultural Statistics, 2002)).

Buffer Type	**Total acres affected**	**Net Present Value of Total Costs to Society**
ANR 50ft	191.479	$1,347,799
Stormwater Center 120ft	340.264	$2,395,079
ANR stream geomorphic assessment ~800ft	1456.05	$10,248,968

[1] We have heard from landowners that hay does not really grow well along the creek being as it is too wet, and it is their most fertile soil, but we believe that it at least gives us some representation of the productive value of the area.

The larger the buffer, the higher the cost of the crops forgone, and the higher the cost to society of seeding a forest or grass buffer. The costs of replacing this crop elsewhere, or buying the crop from elsewhere, are the same as the value of the crop to farmers, so you can assume a 1 for 1 swap rate, assuming we used a yield for hay of about $303 per acre per year (Craig Miner, personal communication). Therefore, these present values are reasonable representations of the actual costs associated to society with implementing a buffer along the 10-mile section of the Otter Creek.

Conclusion

The value of the ecosystem services that would be protected from the buffers is much greater then the costs of implementing the buffer to society in terms of yield forgone, even with applying a relatively low discount rate over the next 30 years (Table 7). This means that it is a worthwhile investment for society to implement the buffer. While these numbers are approximate because of the way that we summarize the 10-mile stretch and because we have estimated from other studies to place values on the creek's ecosystem services, this model still gives us a reasonable idea of the comparison of costs and benefits of putting in the buffer.

Table 7. Benefit of ecosystem services from the Loomis et. al study, and the range of costs associated with the varying buffer sizes.

	Includes	**Value**
Benefit of Ecosystem Services	Dilution of wastewater, natural purification of water, erosion control, habitat for fish and wildlife, and recreation.	19-70 million dollars
Cost of putting in Buffers to society	Cost of crops forgone in terms of hay at $303/acre and the costs of putting in the buffer.	1-10 million dollars

Individual Landowner Decisions

Introduction

Now that we have looked at the costs and benefits of implementing riparian buffers for society as a whole, we must understand how individual landowners make decisions about whether or not to implement riparian buffers (for landowners make the ultimate decisions about their property). For the basis of this analysis we use a study by Lynch and Brown (2000) who looked at the Chesapeake Bay area of Maryland to determine under what conditions a private landowner would establish a riparian buffer, when most of the benefits would accrue to society and not to the landowner. In this analysis we have looked specifically at CREP as the government program providing incentives to farmers along the Otter Creek south of Vergennes to implement buffers. We are using CREP because of the information we have gotten from both Laura Hanrahan and Craig Miner of the FSA, that it is the most feasible conservation program to cover the ANR 50ft buffer, which is the most likely buffer to be implemented at a moderate to large scale in this locality.

Given the choice between conservation of a buffer in CREP, and no conservation, it is commonly believed that farmers will increase their use of buffers if rental rates increase, incentive payment's increase, or the cost-share rates increase. Farmers will decrease use of buffers if net crop price increases, if the discount rate increases, or if the number of acres in crops increases (Lynch, 2000).

Our study is precluded to only farmers who actively use the land for productive purposes along the river, because these are the areas which we observed to be in most need of buffers. What we have found is that under certain circumstances, the net monetary benefits of entering a CREP contract far outweigh the net monetary costs to the individual farmers, showing that it would be most efficient for them to accept society's payments in order to make a greater return on their land by allowing it to provide society with a more natural riparian setting.

Methods

Landowners' decisions can be broken down into a two-stage model (Figure 8). First, the landowner/farmer must choose whether to continue farming/doing what they normally do on their land or sell their land for development. As there is increased demand for residential property in Vermont, especially scenic property along rivers, there are potentially significant financial returns to selling farmland for development, so this is an important decision. If a farmer does not sell land for development and continues to farm and/or own the land, s/he must choose whether to plant a buffer or not (by enrolling in CREP or not); a second decision is to determine the width and type of the buffer s/he will establish, maintain, and/or conserve. Given a set of parameters characteristic to the local area, a discrete decision will be made by landowners to participate or not, "followed by the landowner's optimization of buffer type and size" (Lynch, 2000).

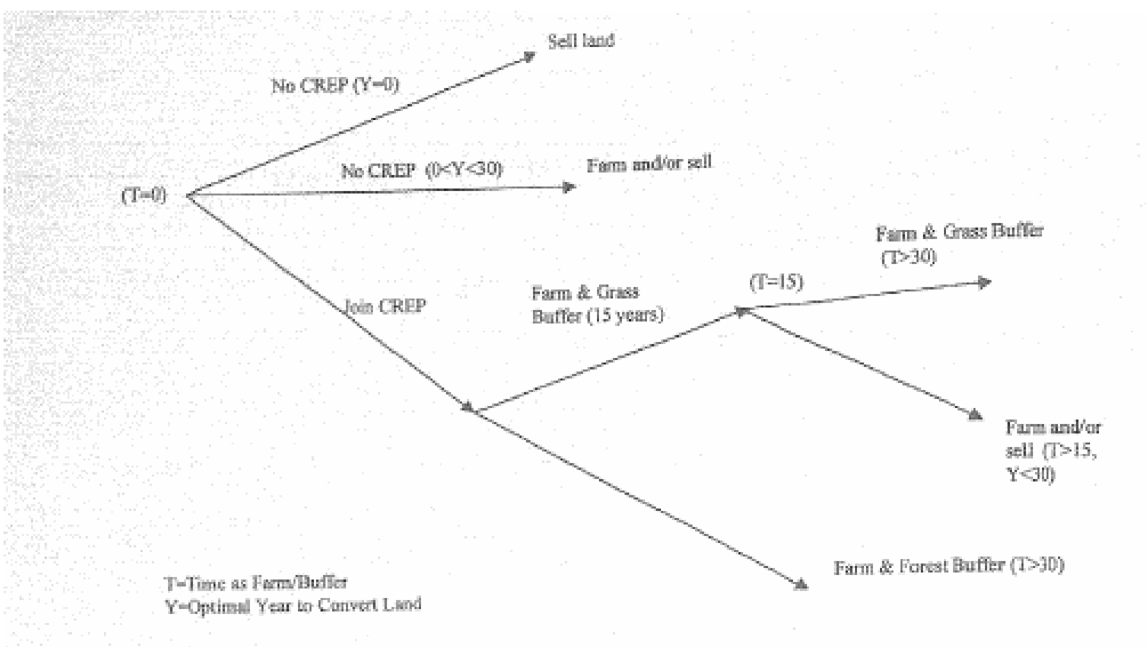

Figure 8. Decision tree.

Many different approaches have been used in the past to examine landowner adoption of conservation programs in exchange for incentive payments. For instance, Konyar and Osborn (cited

in Lynch and Brown 2000) used a discrete-choice approach to predict participation in CRP, and found that "farmer's age, farm size, land value, erosion rate, tenure system (rental or ownership), percentage of income from farming, and expected net returns all influenced the probability of participation." Gasson and Potter (cited in Lynch and Brown 2000) used a different approach, a contingent valuation approach. They found that longer-term conservation practices needed higher rental payments and large growers would on average commit a smaller percentage of their total acreage. The approach taken by Lynch and Brown (2000) is more in-depth than previous papers which they cited because it examined both the decision of whether to participate and the width and type of buffer chosen. Among the parameters considered in this analysis were farmers concerns about the loss of productive cropland, the increased difficulty of maneuvering farm equipment, the presumed increase of the deer population (leading to increases in predation and decreases in crop yield), and the money and time required to establish and maintain the buffers. In addition, the analysis allowed for the opportunity cost of the lost agricultural income and the lost option to make the most profitable sale if the parcel were restricted by a CREP contract and could not be sold at the optimal date (Lynch and Brown, 2000). Participation in CREP does not preclude the landowner from selling the land, as the contracts are transferable.

The complicated model allows the farmer to make discrete choices among several different paths each of which affects the options for the next period. In this model, the farmer will choose the profit maximizing decision, and as expected, it shows that farmers would increase their use of buffers if rental rates, incentive payments, or cost-share rates were to increase. Farmers would decrease use of buffers if net crop price, the discount rate, or the number of acres in crops were to increase. For a closer look at the numbers and results of the Lynch and Brown study please refer to Appendix 5.

In order to get a better idea of how this economic model would play out with the landholders along the Otter Creek and to determine trigger levels for choosing to create buffers, we must run a series of simulations with local data. Unfortunately, we have had to simplify the model quite a bit. What we have done is run an analysis on a representative one-acre plot of land, and the decision to either continue farming on it for the next 15-30 years or to put it into either a forest- or a grass-buffer CREP contract. We did this by comparing the net present values of the benefits from farming over the next 15 or 30 years, in terms of profits on corn (assuming a meager growth rate of 1% in the profit on corn because we have heard from Craig Miner that the price of corn does not change, and given its varying yields from year to year believed this to be acceptable), and compared these to the benefits (rental and incentive payment cash-flows) received from entering a CREP contract.

Results

Table 8 shows the costs associated with putting the corn land out of production over the next thirty years ($3,039) assuming, as Craig Miner suggested, a corn yield of around $400/acre, costs of production between $200-$300 (assumed $250), growth rates of 1%, and a discount rate of 1%. The CREP incentive payment amounts are up-front and based on values per acre of different land-use type per year; those values are multiplied out over the term of the contract and paid up-front. The rental payments are based on $88, the average rental payment for Vergennes Clay, which makes up about 90% of the soil type along the Otter Creek.

Table 8. Prospective 30-year CREP contract.

						CREP incentive payment							
		Costs				Forest				Grass		Land Rental Payments	
Year	Size of plot (acres)	Corn $Yield/Acre(assuming a 1%/yr growth rate)	Average Costs of production for corn(1%/yr growth rate)	Average Profit on Corn	Present Value of profit of crops foregone assuming 4% discount rate	Cropland for 3 of past 6 years	Cropland for 1 or 2 of past 6 years	Cropland for zero of the past 6 years	Marginal Pasture Land	Cropland for 3 of past 6 years	Cropland for 1 or 2 of past 6 years	CREP paymets	Present Value of CREP rental paymentsassuming 4% discount rate
0	1	400	250	150	150	4410	2490	2190	1140	4110	2190	88	88
1	1	404	253	152	146	0	0	0	0	0	0	88	85
28	1	529	330	198	66	0	0	0	0	0	0	88	29
29	1	534	334	200	64	0	0	0	0	0	0	88	28
30		13914	8696	5218	**3039**	4410	2490	2190	1140	4110	2190	2640	**1583**

By adding the incentive payments total value (depending on the past use of the land) to the present value of the CREP rental payments, we can see that it actually pays to put land into a buffer, specifically when the land has been in crop rotation 3 out of the past 6 years (Table 9).

Table 9. Net Present Value of CREP Payments Given Land Use

Cropland for 3 of past 6 years	Cropland for 1 or 2 of past 6 years	Cropland for zero of the past 6 years	Marginal Pasture Land	Cropland for 3 of past 6 years	Cropland for 1 or 2 of past 6 years
$5,993	$4,073	$3,773	$2,723	$5,693	$3,773

Our results clearly show that CREP payments are extremely competitive with the resource rent that farmers earn from growing crops. In all instances, especially when farmland has been in rotation, being used for corn 3 of the past 6 years, no matter what type of buffer they decide to enroll in, forest or grass, they would be better off monetarily with putting their land into a CREP contract. This holds true regardless of whether the farmer uses the feed himself, or sells it.[2] While these results are extremely simplified and use average figures in order to get a feel for the costs to

[2] The farmer who grows corn on his land (and we assume in our model that he would do it every year, not rotating the field with a hay crop) and feeds it to his own animals, would have to then buy the feed from somewhere else. Since the cost of buying feed from somewhere else is the same as the total dollar yield of corn per acre, then his circumstance would be no different than that farmer who sells his product (see Figure 8, Decision Tree).

farmers of entering a contract, we feel that they are representative and demonstrate why it makes economic sense for farmers to implement a CREP-financed buffer.

In our calculations we believe that we are being generous in terms of the ability to make $3,000/acre over the next 30 years because we assume the use of the acreage for production every year with no rotation, which in many cases would ultimately overstate the earning potential of the land. The same results hold true for entering a 15-year contract, as the monetary benefits outweigh the costs of entering CREP.

We have assumed a discount rate of 4% for calculating the Net Present Value (NPV). We believe this is a fairly common rate, because given a dollar today, if you were to invest it or put it into a bond, you could easily expect to return 4% per year. The higher the discount rate, the more you are discounting the future. We do not want to use too low of a discount rate, because we don't want to sacrifice too much of the landowner/farmer's well being today for their well-being down the road. We can assume that the lower the discount rate we use the less attractive the CREP payments will look, because most of the CREP payment comes immediately in the form of the incentive and the costs of giving up the land are accrued equally every year. By running the same analysis using a discount rate of only 1%, we find that the total NPV of CREP payments to a farmer who puts land that has been rotated 1 or more of the past 6 years into a forest or grass buffer is just slightly greater then the NPV of continuing to farm the land every year. Even though it still makes economic sense for individuals to put their land into a CREP program, we do not believe that such a low discount rate should be applied in these circumstances because money in the pocket today, if invested wisely, is worth more then that money 30 years down the road. [3]

[3] An Excel workbook with the full range of economic calculations made for this project can be obtained by contacting Diane Munroe, Middlebury College Environmental Studies Program, (802)443-5925, dmunroe@middlebury.edu.

Conclusion

Being conservative in our analysis we have shown the magnitude of CREP enrollment benefits over time. It is important for farmers/landowners to understand these benefits in comparison to their own spreadsheets, as what we have done is just an example. In our analysis it turned out to be economically efficient to put land into conservation. From here, continued outreach and monitoring is important, and if farmers do question the economic benefits, the spreadsheet attached can be modified to their likings in order to determine whether or not the NPV of the benefits exceeds that of the costs associated with taking their land out of use and implementing a CREP-financed riparian buffer. If it does not make sense, then combining CREP with other public and private programs is a possible route.

Our analysis shows that buffers are more attractive to landowners when discount rates are higher, crop margins are lower, and program payments are higher. Currently, from an efficiency standpoint it makes economic sense for farmers to enter into CREP contracts if they can get approval from the FSA. As noted earlier, we realize that landowners also consider other factors when making such land-use decisions.

Economic Analysis Conclusions

The value of the ecosystem services, along with the potential increases in land value associated with the increasing ecological health of the area, are large. With our brief analysis, it is hard to fully estimate how great the benefits are because we don't know the scope of the ecological benefits that this section of the creek provides. In general, ecosystem services are valued highly, and it would seem that for society as a whole, the net present value of those services would exceed the net present value of the costs of creating a riparian corridor along this 10-mile agricultural stretch of the Otter Creek. Under certain circumstances, however, no matter how much the farmers care about

conservation, they must think about the efficiency of their own land, and so must make discrete decisions about whether or not to participate in programs like CREP, setting aside their land for conservation for a long period of time. As we have seen from the above analysis, their decisions depend upon the levels of payments, including incentives and rental payments from governmental and non-governmental sources, along with crop prices and potential yields; of course, the land's real estate value is also of extreme importance in making decisions about its use.

It does make sense for individuals to implement CREP-funded buffers from an efficiency standpoint. Therefore, we recommend the continued education of landowner's by private organizations like the VRC. We believe that since it seems to make economic sense for society and individuals, no one can really lose out. If farmers knew the potential scope of the CREP payments, and had more assistance (from resources like the Otter Creek NRCD and VRC) in learning how to take advantage of them, the Otter Creek could become a healthier system, and would also become a focal point of natural beauty in the entire locale.

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Part V. Project Conclusion

Just as the land use along the otter creek has changed over the past 60 years, we have heard from some of the landowners that the health of the creek has as well. Since the creek's health is significant to society not only for its recreational purposes, but for its biodiversity, and its historical and future importance as well, it is vital to try to continue changing the landscape to benefit the ecosystem. Given this desire, we have created a number of buffer scenarios along the creek, and while some of the larger buffers might not be plausible, the analyses give future policy-makers and conservationists a springboard from which to jump. By providing a package of GIS layers to VRC we allow them to understand visually what has been, and is, happening along this 10-mile section of the creek.

Given the varying land uses, and the diverse group of stakeholders and interests along the creek, we know that conservation of the riparian corridor is important in some degree to all stakeholders. While not every section of the creek deserves the same amount of attention in terms of implementing a buffer, we have focused our socio-economic analysis mainly around the grazing and cultivated lands near the river, and now at least have some idea of the costs associated to society with taking a buffer out of production. Given the potential scope of some of the benefits, it is rational to see why society as a whole would want to spend its time and money in doing so. However, as not all landowners always see eye to eye on environmental issues, and it is ultimately up to them what they do with their land, we must appeal at the very least to their sense of efficiency in order to help solve this public goods problem. We can see that for some landowners it literally pays to conserve land through a government program. For others, we can advocate the formation of partnerships between organizations such as VRC and government

agencies in order to supplement the incentive programs and work toward protecting the riparian area in perpetuity in a way that farmers can view as economically feasible.

Although the bounds of parcels along the creek are set by private, deeded boundaries, we have witnessed first-hand the creek's own reminders of its dynamic nature. We have seen the flooded areas, the areas of bank erosion, the seasonal inundation of sediment and run-off, and the changes in land-use around the creek. We have seen how and why it makes economic, social, and political sense to take action to create, maintain and protect riparian buffers, both from society's point of view, and individual landowner points of view.

Given each of our team members' diverse backgrounds within the college, we believe that what we have come up with is a model interdisciplinary, dynamic approach to analyzing this riparian environment; our work can be expanded upon in the future. We believe that continued monitoring, continued education, and continued partnerships are needed in order to effect the change that everyone, to varying degrees, wishes to see.

Appendix 1. Landowner Letter of Introduction

Otter Creek Natural Resource Conservation District
68 Catamount Park, Suite B, Middlebury, VT 05753
Phone: 802-388-6746 x 26   Fax: 802-388-3709
E-mail: pam.stefanek@vt.nacdnet.net

April 5, 2005

Dear Landowner,

As partners in conservation with landowners for over fifty years we would like to introduce you to an effort underway along the Otter Creek initiated by the River Conservancy, now with an office in Middlebury. The Vermont River Conservancy, known for creating riverside public access, has tasked Marc Lapin to complete an Analysis and Evaluation of ten miles of the Otter Creek banks from Vergennes south. Marc will be helped in this effort with Middlebury College Senior Seminar students.

The focus of this study will be on the riverbank. Particularly, the interface of the cultural uses and the bank in a natural condition. Where trees are growing along the riverbank providing bank stability and shade and wildlife corridor, that area is now called a riparian buffer.

This study has many aspects, including the economic costs of maintaining riparian buffers, taking a look at policies involved with riparian areas in subdivision language and also conservation easement language, and completing a brief interview with landowners along the creek.

This effort on the ground will take place over a time of about a month. Participants wishing to hear the results of the work can attend the reading at the Environmental Science Colloquium at Bicentennial Hall at Middlebury College on May 5th at 12:15.

Sincerely,
Wes Larrabee

Appendix 2. Design Standards for Forest Buffers, The Center for Watershed Protection (www.stormwatercenter.net)

A) A forest buffer for a stream system shall consist of a forested strip of land extending along both sides of a stream and its adjacent wetlands, floodplains or slopes. The forest buffer width shall be adjusted to include contiguous sensitive areas, such as steep slopes or erodible soils, where development or disturbance may adversely affect water quality, streams, wetlands, or other waterbodies.

B) The forest buffer shall begin at the edge of the stream bank of the active channel.

C) The required width for all forest buffers (i.e., the base width) shall be a minimum of one hundred feet, with the requirement to expand the buffer depending on:1)stream order; 2)percent slope; 3)100-year floodplain; 4) wetlands or critical areas.

The width of the stream buffer varies from twenty feet to up to 200 feet in ordinances throughout the United States (Heraty, 1993). The width chosen by a jurisdiction will depend on the sensitivity and characteristics of the resource being protected and political realities in the community.

1) In third order and higher streams, add twenty five feet to the base width.

2) Forest Buffer width shall be modified if there are steep slopes which are within a close proximity to the stream and drain into the stream system. In those cases, the forest buffer width can be adjusted.

Several method may be used to adjust buffer width for steep slopes. Two examples include:

Method A:

Percent Slope	Width of Buffer
15%-17%	add 10 feet
18%-20%	add 30 feet
21%-23%	add 50 feet
24%-25%	add 60 feet

Method B:

Percent Slope	Type of Stream Use	
	Water Contact Recreational Use	Sensitive Stream Habitat
0 to 14%	no change	add 50 feet
15 to 25%	add 25 feet	add 75 feet
Greater than 25%	add 50 feet	add 100 feet

3) Forest buffers shall be extended to encompass the entire 100 year floodplain and a zone with minimum width of 25 feet beyond the edge of the floodplain.

4) When wetland or critical areas extend beyond the edge of the required buffer width, the buffer shall be adjusted so that the buffer consists of the extent of the wetland plus a 25 foot zone extending beyond the wetland edge.

D) Water Pollution Hazards

The following land uses and/or activities are designated as potential water pollution hazards, and must be set back from any stream or waterbody by the distance indicated below:

1) storage of hazardous substances (150 feet)

2) above or below ground petroleum storage facilities (150 feet)

3) drainfields from on-site sewage disposal and treatment system (i.e., septic systems--100 feet)

4) raised septic systems (250 feet)

5) solid waste landfills or junkyards (300 feet)

6) confined animal feedlot operations (250 feet)

7) subsurface discharges from a wastewater treatment plant (100 feet)

8) land application of biosolids (100 feet)

For surface water supplies, the setbacks should be doubled.

More detailed information at:
http://www.stormwatercenter.net/model%20Ordinances/buffer_model_ordinance.htm

Appendix 3. Riparian zones: Their relevance to town plans and zoning ordinances in the Windham Region of Vermont

(Westing, Arthur H., Putney Commissioner, Windham Regional Commissioner)

Guidelines for Width

1) To stabilize streambanks or lakeshores, and to reduce stream flood damage, a width of 20 feet from the high water mark would appear to be adequate, with livestock trampling and watering points not permitted. Should perennial grasses be resorted to, then the strip would have to be twice as wide.

2) To contribute to the supply of beneficial nutrients in the adjacent waters via dropping of bits of organic debris (both vetegal and animal), and via decomposition and leaching, might require only a strip of vegetation of perhaps 25 feet in width from the high-water mark (although there seem to be no adequate studies from which to make this a definitive estimate).

3) To reduce the entry of dissolved pollutants into the water- for example, fertilizers, pesticides, and animal wastes from farms – requires a rather wider strip of protective vegetation than above. For example, a recent study in Quebec found that the entry into a lake of such pollutants was reduced by about 65% with a forest buffer of 66 feet in width. A recent study in Illinois found that a forest buffer was substantially more effective than a grass buffer, the former requiring about 52 feet (as opposed to 128 feet for the latter) to capture about 90% of the agricultural pollutants studied. As a buffer between farmland and stream the US Forest Service recommends a forested strip of 75 feet in width from the high-water mark, the streamside 15 feet to be left essentially undisturbed and the remaining 60 feet to be treated as a working sustained-yield woodlot—although in areas of steeply sloping riparian land, these widths would have to be increased by up to two times.

4) To create shade for trout and other cold-fishery streams, a width from the high-water mark of 30 feet of trees would seem to be adequate. The width of such shade-producing strips might well be made a but wider on the south and east sides of streams than on their north and south sides.

5) To provide a habitat corridor connecting fragmented woodlands, the width would presumably vary with the fauna meant to be favored, but it might be useful to suggest a minimum width of 250 feet.

Appendix 4. Franklin Soil and Water Conservation District Buffer and Easement Language

Option #1: Voluntary Buffer Establishment-50 ft.
Minimum Width: 50 feet from top of streambank
Minimum Stream Length: Length of property along stream
Financial Benefits: 75% of all project costs including vegetation and installation paid by FSWCD (up to $450 per acre)
Length of Contract: 15 yrs transferable with property, "conservation lease"

Option #2: Voluntary Buffer Establishment -120 to 300 ft.
Minimum Width: 120 feet (average width) from top of streambank
Minimum Stream Length: Length of property along stream
Financial Benefits: 75% of all project costs including vegetation and installation paid by FSWCD (up to $450 per acre), plus a 25% bonus from Darby Creek Association (100% benefit).
Length of Contract: 15 yrs transferable with property, "conservation lease"

Option #3: Conservation Easement Donation
Minimum Width: 120 feet from top of streambank (average width)
Minimum Stream Length: Length of property along stream > 300 ft. preferred
Financial Benefits:

- 100% of all project costs including vegetation and installation paid by FSWCD (up to $450 per acre)
- $150 allowance to seek advice from a tax/real estate advisor
- 100% appraisal, survey, title and closing costs (est. $4,000)
- Potential federal, local, and real estate tax benefits based on appraised easement value

Length of Contract: Transferable with property in perpetuity, "conservation deed"

Option #4 Conservation Easement Purchase
Minimum Width: 120 feet from top of streambank (average width)
Minimum Stream Length: 400 feet along stream length
Financial Benefits:

- 100% of all project costs including vegetation and installation paid by FSWCD (up to $450 per acre)
- $150 allowance to seek advice from a tax/real estate advisor
- 100% appraisal, survey, title and closing costs (est. $4,000)
- Potential federal, local, and real estate tax benefits based on appraised easement value if sold at bargain rate

Length of Contract: Transferable with property in perpetuity, "conservation deed"

http://www.franklinswcd.org/Factshts/BufferOptions.pdf

Appendix 5. Lynch and Brown, 2000 Economic Data

In their study, Lynch and Brown use a representative farm size of 100 acres and assume that no more then 10% of the land can be put into CREP because of the 150ft maximum width constraint. The simulations are also based on a representative corn field in which average profits are $0.59 per bushel, and corn yields about 80-120 bushels per year, and they assume a base case rental rate of the land from CREP of $70, and incentive payments of 50-70% of this are included as well. The costs of installing and maintaining a riparian forest buffer are $575 per acre and costs for a grass buffer are $400 per acre. Farmers can receive up to 100% cost-share for implementing these. The opportunity to sell the trees that have been growing on a forest buffer is also included, however this would only be optimized over a longer period of time, 30 years (even though we have heard from Marc Lapin that trees could not be sold after only 30 years for this amount, but I believe they do have some pulp value) and returns about $1,000 per every 40 acres. From these numbers, a farmer would maximize the present value of profit received from acreage left in agriculture plus the rental and incentive payments for the riparian buffer for 30 years assuming a discount rate of 4%. These numbers are not entirely arbitrary, we use a higher discount rate because we care about farmers' current status, and don't want to sacrifice any of their short-term status for their long-term status; the rest of the numbers come from published research studies. In order to determine the optimal year to sell property, they assumed an appreciation in land value of 3.5% per year, and assume a land value of $2,000 to $10,000 per acre (Lynch and Brown, 2000). Based on these numbers and assumptions, Lynch and Brown were able to run through their model, and find the exact trigger levels at which farmers would enter their land into CREP contracts. Given their base case numbers and assumptions, farmers would enroll as much land as they possibly could into CREP contracts. However, when they started simulating different numbers they were able to find different trigger levels.

Appendix 6. Landowner Contact Information

Parcel #	Last Name	First Name	Phone #	Street Address	City	State	Zip	Town
30023000	Tarte	Paul and Rebecca	877-2454	192 South Maple St.	Vergennes	VT	O5491	Vergennes
30023300	Sullivan	John and Marion	877-3028	200 South Maple St.	Vergennes	VT	O5491	Vergennes
26031900	Huckabay	William and Lucie	877-6632	60 South Water St.	Vergennes	VT	O5491	Vergennes
30020200	Clayton	Kenneth and Donna	877-3183	94 South Water St.	Vergennes	VT	O5491	Vergennes
29021600	Wagner	John and Mary	877-2771	14 Prospect St.	Vergennes	VT	O5491	Vergennes
26031200	Vachon	Paul and Cheryl	877-2718	46 South Water St.	Vergennes	VT	O5491	Vergennes
30021100	Swenor	Neil and Helen	877-6375	140 South Maple St.	Vergennes	VT	O5491	Vergennes
30022400	Suttle	Richard John	877-9940	175 South Maple St.	Vergennes	VT	O5491	Vergennes
25027500	Stephens	John and Mary Sue		8017 N. Santa Monica	Milwaukee	WI	53217	Vergennes
30022800	Scott	James and Dianne	877-9238	184 South Maple St.	Vergennes	VT	O5491	Vergennes
30022400	Rood	Thomas and Julia	877-3072	174 South Maple St.	Vergennes	VT	O5491	Vergennes
26031800	Roger	George	877-2754	74 South Water St.	Vergennes	VT	O5491	Vergennes
30022200	Quesnel	Michael and Jennifer	877-3700	158 South Maple St.	Vergennes	VT	O5491	Vergennes
30021200	Price	Janet	877-3517	8 Ice House Ct.	Vergennes	VT	O5491	Vergennes
29022700	O'Daniel	Trustee Michael	877-2005	25 Hopkins Rd.	Vergennes	VT	O5491	Vergennes
26032200	Magill	Ray and Susan		90 South Water St.	Vergennes	VT	O5491	Vergennes
26032000	Lemieux	Robert	877-1015	86 South Water St.	Vergennes	VT	O5491	Vergennes
30023100	Lanpher	James and Diane	877-2230	P.O. Box 165	Vergennes	VT	O5491	Vergennes
30022900	Lambert	Ruth and Gayle Roosa	877-3005	188 South Maple St.	Vergennes	VT	O5491	Vergennes
26032100	Labombard	Trustee Robert	877-3382	88 South Water St.	Vergennes	VT	O5491	Vergennes
26031500	Humphrey	Anne	877-2855	62 South Water St.	Vergennes	VT	O5491	Vergennes
26031400	Jin	Chaesun and April		58 South Water St.	Vergennes	VT	O5491	Vergennes
30022000	Halpin	Peter and Janet Joppe	877-3531	7 Ice House Ct.	Vergennes	VT	O5491	Vergennes
30010100	Harper	Tommy		P.O. Box 4615	Maury City	TN	38050	Vergennes
25022000	Green Mt. Power		877-3773	163 Acorn Lane	Colchester	VT	05446	Vergennes
30023400	Gevry	Rheal and Gail	759-2465	802 Mountain Rd.	Addison	VT	05491	Vergennes
26031100	Ganson	Wayne and Patricia	877-3608	42 South Water St.	Vergennes	VT	O5491	Vergennes
30020900	Frost	Trustee Albert		104 South Water St.	Vergennes	VT	O5491	Vergennes

26031300	Farrell	Jane		1641 Kit Carson SW	Albuquerque	NM	87104	Vergennes
30020400	Dukette	Marc and Denise	877-1112	96 South Water St.	Vergennes	VT	O5491	Vergennes
25024800	Duffy	Leonard and Carolyn	482-3040	P.O. Box 99	Hinesburg	VT	05461	Vergennes
30022100	Dion	Christopher	877-3163	154 South Maple St.	Vergennes	VT	O5491	Vergennes
30022100	Cloutier	Richard and Margaret	877-2544	156 South Maple St.	Vergennes	VT	O5491	Vergennes
30020800	Childers	Ronnie and Barbara	877-3383	100 South Water St.	Vergennes	VT	O5491	Vergennes
25024900	Casey	Timothy and Melissa	877-3684	19 Scoval Lane	Vergennes	VT	O5491	Vergennes
30022700	Burke	Richard and Evelyn	877-3452	P.O. Box 91	Vergennes	VT	O5491	Vergennes
30020100	Angier	Mark and Elizabeth	877-2486	92 South Water St.	Vergennes	VT	O5491	Vergennes
29022600	Bourgeois	Marcel and Paul	877-2255	78 West Main St.	Vergennes	VT	O5491	Vergennes
30022900	Bodette	James	759-2456	57 Oven Bay Rd.	Addison	VT	05491	Vergennes
26031600	Beil	Elise	877-6648	66 South Water St.	Vergennes	VT	O5491	Vergennes
30022600	Austin	Richard and Penny	877-3057	178 South Maple St.	Vergennes	VT	O5491	Vergennes
30023200	Arel	Charles and Jacqueline	877-2527	196 South Maple St.	Vergennes	VT	O5491	Vergennes
30022500	Bushby	Wayne and Melonie	877-3883	176 South Maple St.	Vergennes	VT	O5491	Vergennes
26031700	Bronwell	Jonathon and Cheryl		70 South Water St.	Vergennes	VT	O5491	Vergennes
1-20-1	Gevry	Gail and Rheal	759-2465	Rd. 1 Box 1734	Vergennes	VT	05491	Waltham
1-20-2	Senesac	Dennis	877-3449	438 Maple St.	Waltham	VT	05491	Waltham
1-20-3	Francis	Harold and Lee	877-2464	564 Maple St.	Waltham	VT	05491	Waltham
1-20-4	Pecca	Stephen and Nancy	877-2278	724 Maple St.	Waltham	VT	05491	Waltham
1-20-5	Charbonneau	Kevin	877-6260	788 Maple St.	Waltham	VT	05491	Waltham
1-20-5	Nowell	Phillip and Diana	877-6359	P.O. Box 24	Vergennes	VT	05491	Waltham
1-20-7	Looby	Carolyn	877-6550	906 Maple St.	Vergennes	VT	05491	Waltham
1-20-7	Ouellette	David		1318 South Middlebrook Rd.	Waltham	VT	05491	Waltham
4-20-1	Buzeman	Herman	759-2336	5198 VT Route 22A	Addison	VT	05491	Waltham
4-20-2	Miedema	Oega and Kimberly	877-0038	1200 Rd. 66	Waltham	VT	05491	Waltham
4-20-4	Gebo	Albert and Valli	877-3547	1894 Maple St.	Waltham	VT	05491	Waltham
4-20-6	Jackman	Robin	877-8306	2142 Maple St.	Waltham	VT	05491	Waltham
6-20-1	Town of Waltham		877-3641					Waltham
7-20-3	Kayhart Farms, Inc.		877-6785	2996 Maple St.	Waltham	VT	05491	Waltham
7-20-4	Martin	Andrew and Catherine	877-6265	3435 Maple St.	Waltham	VT	05491	Waltham

10-20-1	Hallock	Donald	545-2881	1451 Hallock Rd.	Vergennes	VT	05491	Waltham
10-20-2	Etka	Steven D. and Joanna P.	545-2802	4502 Highland Green Ct.	Alexandria	VA	22312	Waltham
10-20-3	Bark	Paul and Janis	545-2600	633 Hallock Rd.	Waltham	VT	05491	Waltham
10-20-4	Field	Harold and Julie	877-2967	581 Hallock Rd.	Waltham	VT	05491	Waltham
10-20-2	Mahan	James and Nancy	545-2004	974 Hallock Rd.	Waltham	VT	05491	Waltham
10-20-5	McKinley	John and Myrdith	545-2284	4058 Quaker Village Rd.	Vergennes	VT	05491	Waltham
075700000	Jackson	George	759-2058	409 Jackson Rd.	Panton	VT	05491	Panton
075300000	Bowden	Michael	759-2178	1059 East Rd.	Panton	VT	05491	Panton
077100000	O'Bryan	Gregory	759-2072	1223 East Rd.	Panton	VT	05491	Panton
076100000	Smith	Andrew	759-3303	21 Fisher Lane	Panton	VT	05491	Panton
076510000	Perry	Ameddia	759-3133	5 Fisher Lane	Panton	VT	05491	Panton
076200000	Dayton	James	759-2168	24 Fisher Lane	Panton	VT	05491	Panton
076300000	Corbett	Edward		1049 Hopkins Rd.	Panton	VT	05491	Panton
077200000	Charron	Bernard	759-2877	1147 Hopkins Rd.	Panton	VT	05491	Panton
072712000	Pelletier	Terry	759-6001	1573 Hopkins Rd.	Panton	VT	05491	Panton
072100000	Giovanella	Louise	759-2921	1530 Hopkins Rd.	Panton	VT	05491	Panton
072720000	Presson	Todd	759-2148	1781 Hopkins Rd.	Panton	VT	05491	Panton
072500000	Goodkind	Penelope	759-2310	1259 Hopkins Rd.	Panton	VT	05491	Panton
026400000	Smith	Dale		831 Hopkins Rd.	Panton	VT	05491	Panton
076400000	Blacklock	Brian		145 Fisher Lane	Panton	VT	05491	Panton

Appendix 7. Landowner Survey[4]

Land Use	
1	Is your land next to and near the river actively used for farming or agriculture?
If Yes	
A	What crops are you growing? (Is the land currently in use for hay, corn other?)
B	How often do you harvest?
C	Are crops rotated in the fields next to the river?
D	Do you farm it or is it leased to a farmer?
If No	
A	What are the primary uses of the land?
2	Do you raise cattle or other animals?
A	Do you have a manure storage tank or pond?
B	Was construction of that partially funded by NRCS or the State?
C	If pastured, do cattle graze down to the river, or are they fenced away from the water?
3	Do you use any herbicides (weed-killers) or fertilizers on your lawn? If so which products.
4	Have you or a previous landowner done any work along the creek to stop erosion of the bank? If yes, what kind and how long ago?
Values	
1	What do you think of the health of the creek? (e.g. Is the water is clean? Is the creek is good quality habitat for fish?)
2	What do you think about the health of the area alongside the creek?
3	How do you and your family use the river? (Irrigation, Swimming, Fishing, Boating, Nature Viewing, Hunting, No Use)
4	Do you feel that protection of the creek's water quality is unimportant, important, or very important?
5	Do you feel that protection of the habitat alongside the creek is unimportant, important, or very important?

[4] Actual survey responses can be obtained by contacting Diane Munroe, Middlebury College Environmental Studies Program, (802) 443-5925, dmunroe@middlebury.edu

6	How could a riparian buffer change the value of your land?
7	How willing would you be to create a conservation buffer along the river on your land? Not willing, not sure, willing?
8	Would you be more likely to work toward creating a riparian buffer if neighboring landowners did also?
Conservation	
1	Are you involved in any conservation programs?
if Yes	
a	Which ones?
b	Why did you choose the program(s)?
c	If not, why not?
2	Have you received State or Federal money as part of a conservation program?
3	Do you know if you are eligible for any government programs or for any land trusts?
4	What do you know about the available programs?
5	Have you ever applied for any or talked with NRCS, FSA, State or land trust people about them?